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DISCUSSION DRAFT

PARTIAL EXPLORATION PLAN
ENVIRONMENTAL BASELINE DATA COLLECTION
AND MONITORING ELEMENT

FEDERAL OIL SHALE PROTOTYPE LEASING PROGRAM
TRACTS U-a AND U-b UTAH

TRACT U-a

SUN OIL COMPANY
P.O. BOX 2880
SOUTHLAND CENTER
DALLAS, TEXAS

AND

PHILLIPS PETROLEUM COMPANY
786 FRANK PHILLIPS BUILDING
BARTLESVILLE, OKLAHOMA 74003

TRACT U-b

WHITE RIVER SHALE OIL COMPANY
300 ENTERPRISE
GRAND JUNCTION, COLORADO 81501

JULY 1, 1974

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SECTION I

INTRODUCTION

FEDERAL OIL SHALE PROTOTYPE LEASING PROGRAM
TRACT U-a and TRACT U-b
PARTIAL EXPLORATION PLAN

ENVIRONMENTAL BASELINE DATA COLLECTION AND MONITORING PROGRAM ELEMENT

SECTION I

INTRODUCTION

A. GENERAL

This Partial Exploration Plan draft (referred to as the "Plan") has been prepared jointly by the lessees for Tracts U-a (Sun Oil Company and Phillips Petroleum Company) and U-b (White River Shale Oil Corporation) pursuant to Section 10 (d) of the respective Oil Shale Leases U-25918 and U-26194.

This Partial Exploration Plan is specifically directed toward the activities relating to the Environmental Baseline Data Collection and Monitoring Program and associated requirements. As such, it does not include the complete Geologic Exploration element which must be ultimately implemented to define the oil shale resources of the tracts. The Geologic Exploration element is currently being prepared and, when completed, will be submitted later as a supplement to this plan for review and approval by the Mining Supervisor.

B. THE PLAN

This Partial Exploration Plan details the two respective lessee's plans for implementing a joint integrated environmental program on both Tracts U-a and U-b. This program, which includes collecting baseline data and establishing comprehensive environmental monitoring activities to be conducted through the initial two-year period, will clearly define and document the environmental conditions that exist on the tracts prior to any development. This will provide the essential predevelopment planning information which, together with engineering and economic data, will serve as a basis for the physical planning and design of oil shale mining and processing facilities and preparation of the Detailed Development Plan (DDP).

The program proposed to be conducted on and adjacent to the tracts includes:

(1) Preliminary Environmental Investigations;

(2) Environmental Baseline Data Collection and Monitoring Programs, including:

- °Surface and Ground Water Resources Investigation and Sampling
- °Air Quality and Meteorological Monitoring
- °Biological Resources Investigation
- °Geology, Soils and Seismicity Surveys
- °Historic, Scientific and Aesthetic Resources Surveys

In addition to these environmental programs, the lessee's have

included preliminary plans for fish and wildlife management, erosion control, surface rehabilitation, and site facilities, as well as other special interrelated program activities. These plans are initially applicable to the environmental and related exploratory field work and, as such, are subject to refinement as the environmental program proceeds and additional information is acquired. Ultimately complete and final long-range plans will be developed which will be included in the Detailed Development Plan submittal. Support activities such as aerial photography and topographic mapping techniques are also described, as related to basic mapping procedures, photogeology and biological monitoring.

It is intended that continuous monitoring of selected environmental parameters will be conducted throughout the development phase and subsequent to the cessation of operations to provide:

(i) a continuing record of environmental changes from conditions existing prior to any development, as established by the initial baseline data program;

(ii) a continuing verification of compliance with provisions of the lease and applicable environmental protection and pollution control requirements;

(iii) immediate elucidation of detrimental effects and conditions requiring correction; and

(iv) a factual basis for possible revision or amend-

ment of the lease stipulations.

This Partial Exploration Plan may be supplemented or modified as indicated by analyses of data gathered. However, any such revisions or amendments will be implemented only after approval is obtained from the Office of the Oil Shale Mining Supervisor, in compliance with the lease stipulations. In addition, monthly activity reports will be submitted to the USGS, BLM, EPA Utah Division of Wildlife Resources and all other involved agencies.

The environmental program element presented in this plan will constitute a significant portion of the total effort during the next two and one-half (2½) years. Requirements relating to water resources, meteorology, and air quality are reasonably well defined at this time and can be initiated almost immediately upon receipt of formal approval of this proposed Exploratory Plan. Detailed biological studies and archaeology-paleontology investigation can be initiated soon after completion of preliminary site surveys (non-destructive field walk-through and aerial photography operations).

In compliance with the lease regulations, none of the field investigative or data collection efforts proposed herein are considered to be an integral part of the Detailed Development Plan (DDP) itself, nor will any subsequent geologic exploration work that may be required to collect resource data.

The scope of the proposed environmental program and the method-

ologies to be employed in conducting the program will be coordinated with interested local, State, and Federal agencies and other influencing groups to insure coordination of the program with any related activities planned or currently underway by those bodies. Further, these groups will be advised of the progress and results of the environmental program on a continuing basis through the life of the activity.

C. DEVELOPMENT GOAL

1. It is the mutual intent of the respective lease operators (Sun Oil Company-Phillips Petroleum Company, and White River Shale Oil Corporation) to develop commercial shale oil mining and synthetic petroleum processing facilities on or near the proposed tracts at the earliest date feasible. Consistent with this goal, the sponsoring companies anticipate submitting the Detailed Development Plan (DDP) in late 1976. It is therefore essential that the Environmental Baseline Data Collection Program be: (i) implemented, sustained, and completed at the earliest feasible date to insure maintenance of the program schedule and (ii) that the methodologies selected for collection, documentation, analysis, and reporting of the data be of such relevance as to insure the early concurrence and approval by the Office of the Oil Shale Mining Supervisor and other permitting and influencing agencies.

D. PERMITS AND APPROVALS

All necessary permit requirements and approvals will be obtained

prior to initiation of the proposed monitoring and data collection activities. A thorough investigation is currently being made of all relevant requirements. These include special land use and drilling permits; approval for disposal of discharge from pumping tests, permit requirements concerning drilling and monitoring site preparation, rights-of-ways and casements for access roads and power lines, restoration of disturbed areas, collection and trapping permits for biological field studies, and approval of archaeological and paleontological survey activities. All other necessary application will be made and appropriate approvals will be obtained from Federal, State and local agencies as applicable to the Partial Exploration Plan.

SECTION II

GEOLOGIC EXPLORATION PROGRAM

SECTION II

GEOLOGIC EXPLORATION

Core hole drilling information obtained during the nomination stage of the prototype oil shale leasing program is just now becoming available to the lease holders. Analysis of this existing resource data by competent geologists, hydrologists, and mining engineers will be necessary before an additional coring program can be fully defined and a geologic exploration plan developed.

The pre-exploratory survey of the lease areas, under way at the present time, will provide data on environmentally sensitive areas not conducive to core hole drilling operations. Exact locations for drilling operations will be surveyed by the operator's engineers, along with involved State and Federal agencies. Wherever possible, multi-functional holes will be drilled to provide data for resource evaluation, hydrologic testing, soils surveying, and rock mechanics, etc. This procedure will save time and will minimize the number of drill sites and consequent surface disturbance.

The drilling program and other exploratory and research operations necessary to obtain complete resource data will be described in a later supplemental plan to be filed with the Office of the Oil Shale Mining Supervisor.

SECTION III

LOCATION AND DESCRIPTION OF OIL SHALE PROPERTIES

SECTION III

LOCATION AND DESCRIPTION OF OIL SHALE PROPERTIES

This Partial Exploration Plan applies to both Tract U-a and Tract U-b of the Federal Oil Shale Prototype Leasing Program. General tract location is indicated in Plate 1, with respective tract boundaries delineated on Plate 2. Both tracts are located adjacent to the White River in Uintah County, Utah, approximately 50 miles southeast of Vernal and approximately 5 miles south of the town of Bonanza.

The respective tracts include the following areas:

Tract U-a

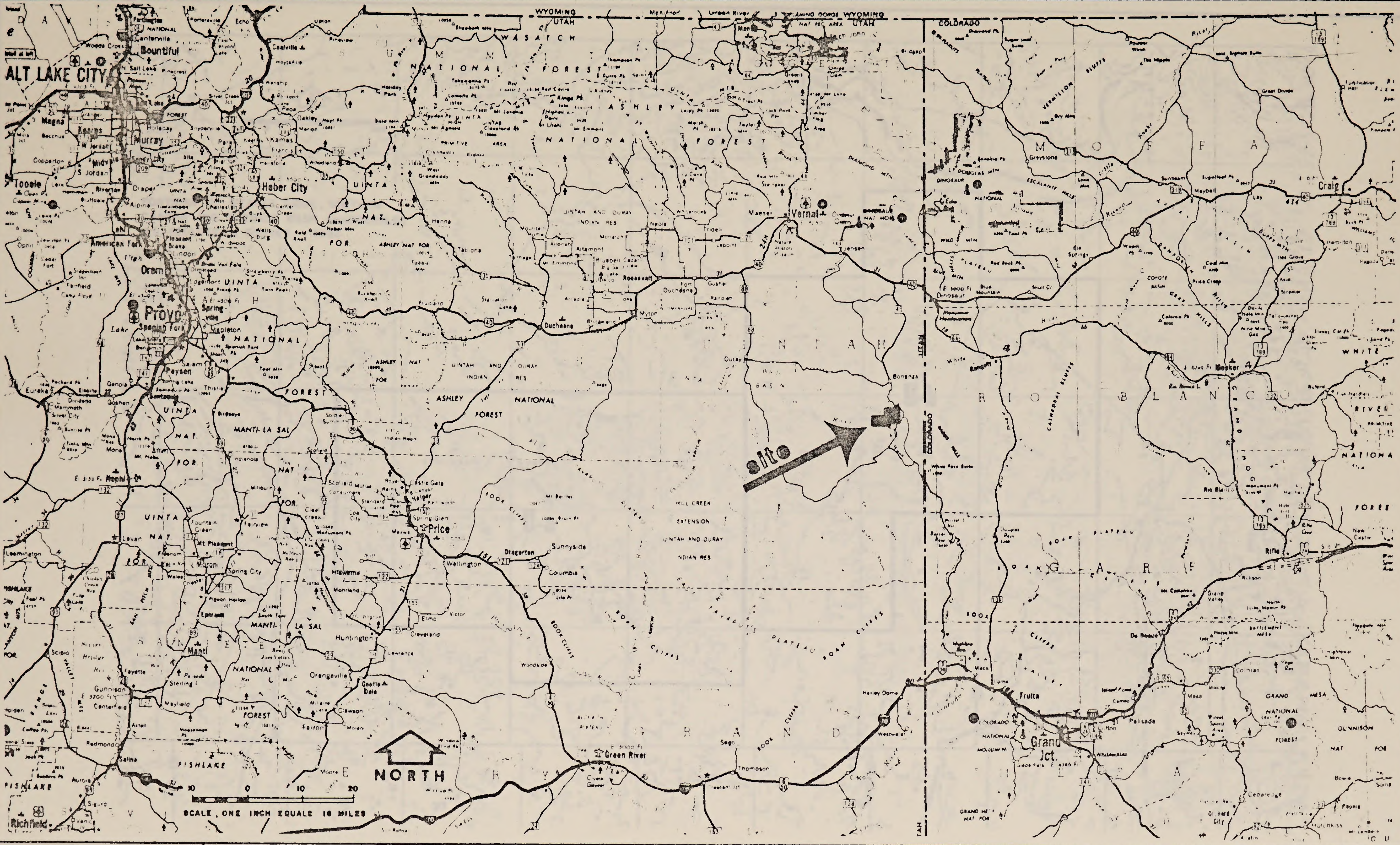
T. 10 S., R. 24 E., Salt Lake Meridian
Sec. 19, E 1/2
Sec. 20, all;
Sec. 21, all;
Sec. 22, all;
Sec. 27, all;
Sec. 28, all;
Sec. 29, all;
Sec. 30, E 1/2;
Sec. 33, N 1/2;
Sec. 34, N 1/2,

(The area described aggregates 5,120.00 acres.)

Tract U-b

T. 10 S., R. 24 E., Salt Lake Meridian
Sec. 12, S 1/2, S 1/2 N 1/2;
Sec. 13, all;
Sec. 14, all;
Sec. 23, all;
Sec. 24, all;
Sec. 25, W 1/2 W 1/2;
Sec. 26, all.
T. 10 S., R. 25 E., S.L.M.
Sec. 18, all;
Sec. 19, all;

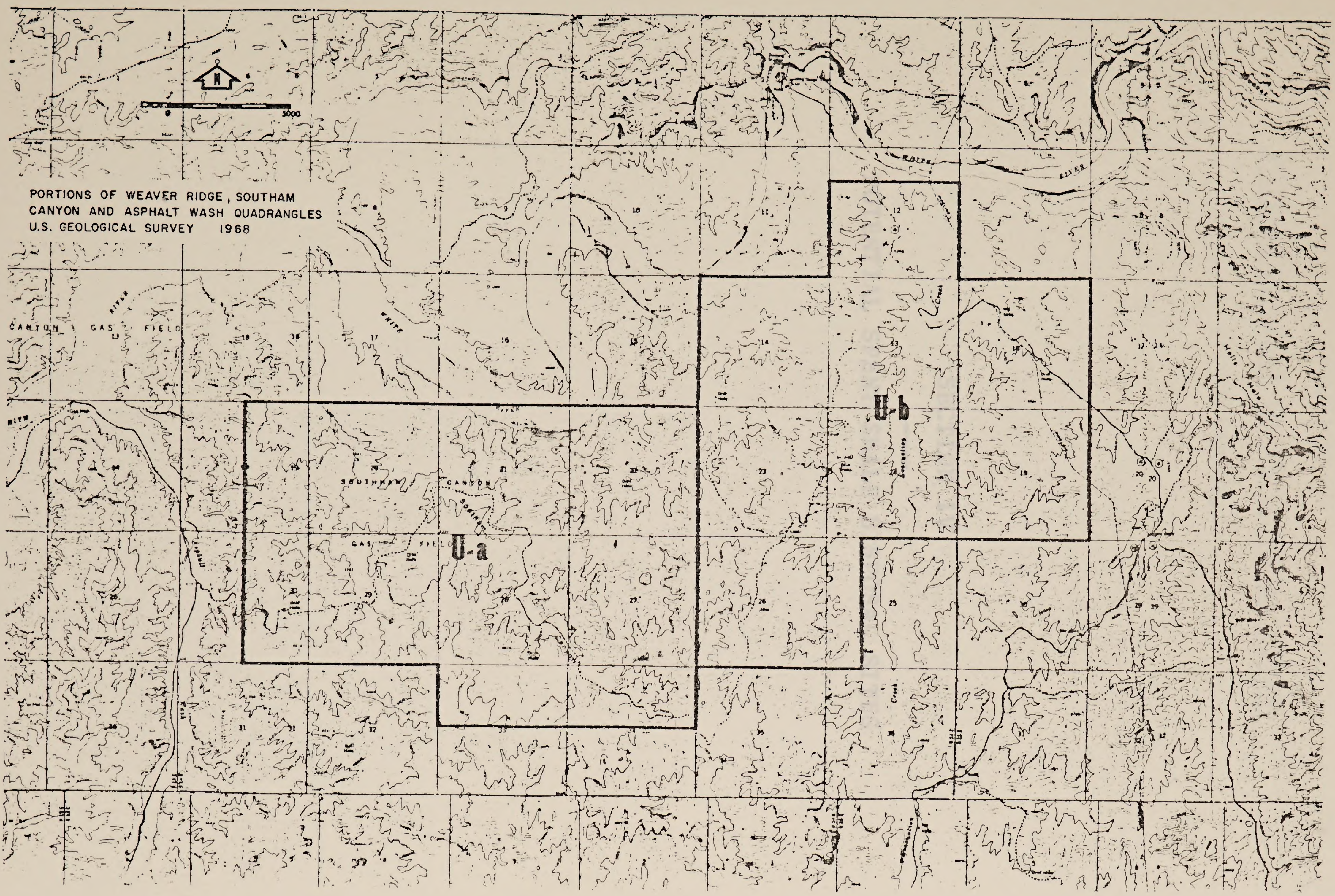
(The area described aggregates 5, 120.00 acres.)



LOCATION MAP OF PROJECT AREA

TRACTS U-a AND U-b

PLATE 1



PORTIONS OF WEAVER RIDGE, SOUTHAM
CANYON AND ASPHALT WASH QUADRANGLES
U.S. GEOLOGICAL SURVEY 1968

BOUNDARIES OF OIL SHALE TRACTS
U-a & U-b

PLATE 2

SECTION IV

POTENTIAL SPENT SHALE DISPOSAL SITES

SECTION IV

POTENTIAL SPENT SHALE DISPOSAL SITES

(Forthcoming)

SECTION V

PRELIMINARY ENVIRONMENTAL INVESTIGATIONS

SECTION V

PRELIMINARY ENVIRONMENTAL INVESTIGATIONS

The lease operators have conducted preliminary investigations prior to the initiation of specific environmental data collection activities in such a manner as to avoid undue environmental damage from the Exploration Program. These investigations are non-destructive and are not substitutes for the required environmental baseline data collection and monitoring programs, but are supplements thereto. The principal areas of preliminary field investigations pertain to:

(1) Biological Resources
   - Plant and animal ecology
   - Aquatic ecology

(2) Historic and Scientific Resources
   - Archeology
   - Paleontology
   - Historic Sites

(3) Meteorology and Climatology

(4) Surface Hydrology

The main objective of these initial surveys was to provide adequate environmental data prior to the exploratory disturbances contemplated to avoid and mitigate surface disturbance or destruction of environmental values. The plant and animal survey provided background on the type and conditions of flora and fauna existing on the areas which may be most sensitive to disturbance. This information was incorporated in the planning of facility locations

and monitoring sites, access routes, etc. A preliminary field assessment was conducted to identify any rare or scientifically significant species or special features of interest such as springs or objects of historic interest. Surface water quality samples were taken, but no soil samples, vegetation species or other items were removed from the tracts pending approval of the formal plan.

SECTION VI

ENVIRONMENTAL BASELINE DATA COLLECTION AND MONITORING PROGRAM

SECTION VI

ENVIRONMENTAL BASELINE DATA COLLECTION AND MONITORING PROGRAM

The scope, methodology, organization, timing, objectives, and on-site equipment related to the environmental data collection and monitoring programs proposed to be carried out on the lease tracts are described herein.

A. WATER RESOURCES

1. SURFACE HYDROLOGY

Lease stipulations as outlined by the Bureau of Land Management, "Modification of Oil Shale Withdrawal in Colorado, Utah and Wyoming," requires the following surface water baseline monitoring program:

- °Gaging stations shall be constructed on the major drainages...and, as required by the Mining Supervisor, upstream and downstream from the lease lands.
- °Data collected at the stations shall include continuous stream level, specific conductivity and water temperature records.
- °Periodic analyses for selected inorganic and organic chemical constituents.

The system of water quality monitoring and stream gaging stations described below is designed to meet and often exceed these

requirements and to afford additional capability to detect any adverse effects caused by the related oil shale development activities which take place off the two tracts.

The location of sampling and stream gaging stations were selected to provide data from the significant water courses which could be affected by shale oil development on Tracts U-a and U-b.

Final selection of the necessary upstream and downstream water quality and stream flow stations will be done after consultation with representatives of the Utah District Water Resource Division of the USGS, EPA, and other interested agencies, and with the approval of the Mining Supervisor. Site visits with the USGS will enable the exact locations of these monitoring stations to be marked in the field. Criteria for the positioning of these stations were based on a number of factors:

°Environmental considerations (adverse impacts, etc.)
°Size of watersheds or stream
°Seasonal accessability
°Configuration of stream channel
°Location of potential spent shale disposal sites
°Position of watershed in relation to the tracts and the related surface development.

The design and construction of these stations and the selection of equipment for monitoring the various water parameters will be done under the supervision of the USGS. Figure shows the

tentative location of the water quality monitoring stations. More stations may be added as data becomes available or the need for more stations is apparent.

A cooperative program will be undertaken with the Utah District of the USGS to supervise the stream gaging and water quality monitoring program. The following list delineates the activities proposed to be performed by the USGS in conjunction with lessee activities.

1. Visit each station at least once per month.
2. Calibrate all equipment as required.
3. Perform water sampling and stream gaging on a periodic basis to be determined by the USGS.
4. Collect and process punched tapes and recording charts from each monitoring station once per month.
5. Provide lessees with preliminary and final data as follows:
   monthly water quality punched tapes for turbidity (5 stations)
   and temperature and conductivity
   monthly water stage punched tapes (13 stations)
6. Conduct water quality analyses on grab samples collected by both USGS and VTN hydrographers.
7. Conduct suspended solids analyses on samples taken on White River and Evacuation Creek.
8. Collect bottom sediment samples four times per year at all water quality stations.

a. Methodology

All stream gaging stations will be equipped to continuously record water level (state) fluctuations. Every water quality station will be equipped to continuously record water temperature and conductivity. Critical water quality stations such as those on the White River and Evacuation Creek will be equipped with single state samplers and turbidimeters. Until the equipment can be obtained to stock these monitoring stations, a rigourous grab sample program will be employed to collect representative background data. Daily water samples will be collected for temperature, conductivity and suspended solids. Sampling and analysis programs will include the following:

Trace Elements

Development of the oil shale will require the removal, processing and disposal of vast quantities of oil shale. Consequently, background or baseline data on the concentrations of these constituents in both ground water and surface water must be determined if the impact of development on water quality is to be assessed.

Trace elements to be analyzed for in the program should include: arsenic, barium, berylium, boron, cadmium, copper, chromium, mercury, lead, lithium, selenium, manganese, silver, molybdenum, tin, and zinc. Sufficient surface water samples should be collected to define variations in the above constituents with streamflow which will require sampling at various streamflow

conditions in addition to specifiec time intervals.

Inorganic Chemicals

Analysis will be conducted under the inorganic chemical program for the standard list of cations and anions, alkalinity, total dissolved solids, suspended solids, pH, turbidity, color, odor, nitrates, nitrites, organic nitrogen, ammonium, nitrogen, and total phosphate. Initially it is planned to perform these tests twice a month on samples from all stations. After the first year of monitoring, it may be possible to reduce this program and sample on a less frequent period.

Organic Constituents

Virtually no background information exists on the occurrence and distribution of organic constituents in the surface and ground water of the Uinta Basin. Therefore, the initial sampling program should be a screening program to identify those groups of organic components that have the greatest solubility in water. This would include members of the following reactive groups: acids, alcohols, aldehydes, ketones, poly hydroxy compounds, phenols, bases, amines, and sugars. In addition, the polycyclic aromatics, petroleum and starch groups of organic compounds should be considered because of the large volume of material that will be handled in the oil shale area. The seasonal variation of these constituents is not known; therefore, ground water should be sampled quarterly and streams over the entire range of discharge and seasons to define the variation.

Measurements of biochemical oxygen demand, dissolved organic carbon, and suspended organic carbon can be used as indicators of gross changes in the functional groups listed above. These measurements can be used to determine if changes in the background organic chemistry have occurred. If changes are found then analyses can be run to determine which of the above groups have changed. Table 1 summarizes the surface water analytical program.

Sediment Program

In any mining environment there is a potential for discharge of large amounts of particulate matter in streams. A sampling program to define the suspended-sediment discharge of streams draining the oil-shale area should be initiated. Suspended-sediment concentration increases as a result of increased streamflow and the associated increased convergence and turbulence.

Single stage samplers, turbidimeters and daily grab samples will be used to define the sediment characteristics of the White River and other flowing streams on the two tracts. Grab sample programs can be effectively employed to measure the suspended solids at several depths and at different locations within any stream cross-section.

A special program of bed sediment sampling at every water quality station will be employed four times a year. Bottom sediment samples will be collected and analyzed for mineralogy, particle size distribution and color photo micrographs.

TABLE 1

SURFACE WATER QUALITY ANALYTICAL PROGRAM

CONSTITUENT	CONTINUOUS	SEMI-MONTHLY	MONTHLY	QUARTERLY	SEMI_ANNUALLY
Specific conductances	X				
Temperature	X				
Turbidity	X				
Dissolved Solids		X			
Suspended Solids	Daily	X			
Dissolved Oxygen		X			
PH		X			
Silica		X			
Calcium		X			
Magnesium		X			
Sodium		X			
Potassium		X			
Ammonia		X			
Nitrate		X			
Nitrate		X			
Total Kjeldahl N		X			
Sulfate		X			
Total Phosphorus		X			
Ortho Phosphorus		X			
Chloride		X			

CONSTITUENT	CONTINUOUS	SEMI-MONTHLY	MONTHLY	QUARTERLY	SEMI-ANNUALLY
Carbonate		X			
Bicarbonate		X			
Fluoride		X			
Boron		X			
Aluminum		X			
COD		X			
BOD		X			
Phenols		X			
TOC		X			
TC		X			
Sulfide			X		
Lithium			X		
Barium			X		
Chromium			X		
Arsenic			X		
Selenium			X		
Cadmium			X		
Copper			X		
Iron			X		
Nickel			X		
Vanadium			X		
Lead			X		
Manganese			X		
Silver			X		

CONSTITUENT	CONTINUOUS	SEMI-MONTHLY	MONTHLY	QUARTERLY	SEMI-ANNUALLY
Bismuth			X		
Cesium			X		
Cobalt			X		
Gallium			X		
Tin			X		
Strentium			X		
Titanium			X		
Thorum			X		
Yttrium			X		
Zercenium			X		
Dissolved gas			X		
Radium 226				X	
Uranium (dissolved)				X	

CONSTITUENT	CONTINUOUS	SEMI-MONTHLY	MONTHLY	QUARTERLY	SEMI-ANNUALLY
Zinc			X		
Oil & Grease			X		
Carbon Chloroform			X		
Total Coliform			X		
Fecal Coliform			X		
Fecal Strep			X		
Mercury			X		
Beryllium			X		
Molybdenum			X		
ABS			X		
Chlorophyll A			X		
Gross Alpha & Beta			X		
Color				X	
Odor				X	
Asbestos				X	
Aquatic Micro-organisms				X	
Amines				X	
Aldehydes				X	
Ketones				X	
Polycyclic Aromatics				X	
Pesticides					X
Herbicides					X

CONSTITUENT	CONTINUOUS	SEMI-MONTHLY	MONTHLY	QUARTERLY	SEMI-ANNUALLY
Complete Element					X
Scan for all					X
Trace elements					X

Aquatic Macroinvertebrates

Aquatic macroinvertebrates can serve as an excellent integrating indicator of water quality. It is essential that the numbers of individuals and species of periphyton and aquatic macroinvertebrates be defined for streams in their existing condition and be monitored as the oil-shale industry develops to document any changes. Changes in the biotic community will reflect changes in water chemistry. Natural changes in water chemistry occur with changes in streamflow. Consequently, the aquatic macroinvertebrates should be sampled seasonally to determine the natural variation. Measurements of pH, temperature, and specific conductance as well as samples for trace element analyses must be made in conjunction with the macroinvertebrate samples.

2. GROUNDWATER HYDROLOGY

(Forthcoming)

B. AIR RESOURCES

A comprehensive two-year atmospheric monitoring program, which in all respects exceeds the requirements stated in section 1(c)(2), paragraph (c) of the Oil Shale Lease Environmental Stipulations, will provide data on meteorological factors and air pollution levels in order to define current baseline air quality against which future trends can be compared, and to determine the capability of the atmosphere in the tract areas for dispersing any pollutants which may be generated there in the future. This information will then be utilized, and appropriate dispersion modeling techniques, to assess the expected air quality impact of plant operations and to assist in the selection of the optimum plant site location in compliance with the National Environmental Policy Act of 1969.

The overall air resources impact assessment approach divides into five phases, the first of which begins concurrently with approval of this plan:

Phase 1 - Acquisition, calibration, and installation of monitoring equipment and field facilities.

Phase 2 - Two-year baseline data acquisition program and supplementary experiments.

Phase 3 - Establishment of air quality related plant siting criteria and selection of plant site.

Phase 4 - Assessment of air quality impact of the development and operation of the plant and of its compliance with applicable air quality standards, and consideration of mitigating measures.

Phase 5 - Continuous air quality monitoring during plant construction and subsequent operation.

Phase 1 is followed by Phase 2, while Phases 3 and 4 take place during the course of and immediately subsequent to Phase 2. Phase 5 would begin after approval of the development plan and completion of Phase 2.

The tools to be used in this work include a comprehensive array of state-of-the-art analyzers, sensors, and analysis techniques, combined with a number of classical approaches and, in cases where the uniqueness of the situation warrants it, some very recently developed (but properly validated) equipment and analytical tools. Equipment and analysis are used as required to meet the needs defined earlier, with the lease stipulations serving as a guideline for the minimum amount of equipment required.

1. AIR QUALITY

Tracts U-a and U-b currently contain few anthropogenic sources of air contaminants, with the major one being Utah highway 45 (an unpaved lightly-used road) which passes through tract U-b. With the exception of minute automotive emissions, dust is the only pollutant, arising from vehicular traffic on dirt roads and from seasonal migrations of sheep herds through the tracts. The only nearby development of any consequence is in the vicinity of the small town of Bonanza, some 4 miles north of the nearer of the two tracts (U-b; where gilsonite mining and crushing, and truck traffic, create particulates. More significant

developments exist in the vicinity of Vernal (about 40 miles NNW) and Grand Junction (about 65 miles SSE). Thus air quality in the lease areas is presently governed almost exclusively by the conditions of air masses which have been transported into the area over long distances of essentially source-free countryside, with little contribution from local sources, and is therefore fairly uniform throughout the two tracts. Future tract development and subsequent mining and processing, along with related activities, will thus become the only significant sources of air pollution in this area.

a. Methodology

The approach to the collection of baseline air quality data involves, first, a network of fixed air quality monitoring stations within the two tracts and in nearby locations. These stations will monitor air quality continuously for the entire two years of the baseline study period, thereby providing detailed data on conditions in the lease areas, in areas upwind of them in which the local background levels are defined, and in downwind locations which are likely to be receptors of whatever air pollution will subsequently be generated within the tracts.

Second, a number of experiments will be performed regularly during the two-year period to better define current conditions with regard to visibility, suspended particulate size distribution, soiling, and carcinogens and radiation in the air. These would all be factors of concern for the health and welfare of individuals residing in the vicinity of the tracts, and their baseline

levels should be assessed. Also, the current impacts of local sources such as the town of Bonanza and of highway 45, will be measured in several separate experiments during the cominant atmospheric regimes.

A total of eight sites will be instrumented for the continuous monitoring of sulfur dioxide (SO_2), hydrogen sulfide (H_2S), and suspended particulates (SP). Three of these eight will also monitor reactive hydrocarbons (HC, defined as total hydrocarbons less methane), nitrogen dioxide (NO_2), carbon monoxide (CO), and ozone (O_3). Federal Air Quality Standards currently exist for all of these pollutants except for H_2S. The monitoring instruments to be used (which are described in detail in the following section), also measure total hydrocarbons (THC), methane (CH_4), nitric oxide (NO, and total oxides of nitrogen (NO_x), all of which are of interest for certain special purposes and will thus be recorded.

All of these pollutants will be measured continuously (i.e., one reading every 10 minutes or more frequently) except for suspended particulates, which will be measured by taking a 24-hour high-volume sample once every 6 days. This is considered adequate by the EPA for satisfying the monitoring requirements of the suspended particulate air quality standard.

Since significant variation in pollutant concentrations is not expected from station to station because of the absence of local sources, extremely detailed monitoring is not warranted for those pollutants which are not expected to be generated by the oil shale

operations in significant quality (e.g., NO_x and CO) and thus would be of concern only in the immediate proximity of their sources. Nor is spatial detail needed for primary pollutants which are only of concern because they serve as reactions in large scale photochemical reactions (e.g., HC), nor for the products of these reactions (e.g., O_3). Thus only three stations are proposed for the monitoring of the photochemical reactants HC and NO_x and for their product O_3, as well as for CO. These stations will provide quite adequate resolution of the spatial variability of these pollutants.

The lease stipulates that one station per trach must be located at the expected point of maximum concentration of air pollutants. Since meteorological details of the area do not exist, nor will plant sites be definitively assigned until the monitoring study is well underway, precise determination of the point of maximum concentration is not possible at this time. However, locations of points likely to receive pollution from possible plant sites have been deduced on the basis of experience with typical flows in complex terrain under low-dispersion stable conditions. Other stations have been sited in probable background and potential receptor areas. The exact locations for these eight stations, and the rationale for their siting, are presented in the next section.

After the first year of monitoring is completed, the site locations will be reviewed. If, on the basis of the data obtained by then, it is concluded that one or more stations are providing redundant data, or that more significant information could

be obtained at a different location, then stations will be relocated as required. Similarly, if the proposed plant locations in the development plan or the actual meteorology differ significantly from that assumed for the site definition in the plan, then the appropriate air quality and meteorological station(s) will be moved to properly document conditions in areas likely to be affected by the plant operation.

A mobile air quality station, containing equipment identical to that in the three full stations, will be used to supplement the eight fixed stations and to assist in defining any changes in s station location which might be needed after the first year. This station will also be used to explore in detail the air qualtiy around current source areas, such as around the town of Bonanza and along highway 45 and, conceivably, the oil fields further north.

Visibility in the oil shale lease area is currently very good and any degradation of this aesthetic factor would be of reasonable public concern. To obtain baseline information on visibility, an integrating nephelometer will be installed at one of the air monitoring stations. This instrument will continuously monitor the light scattering properties of the atmosphere, which can be directly related to the visibility in a well-devined quantative manner. Periodic photography of distant vistas for one full day each month will provide an easily interpretable reference for the continuous point measurements made by the integrating nephelometer.

The size distribution of ambient particulates is important, since only particles in a narrow size range can affect the human respiratory system, while much larger particles can dominate the mass collected by the high-volume sampler. Coincidentally the particulate size range which most affects visibility is also that which most remains in the respiratory system, thus the integrating nephelometer provides some information in this regard. The AISI tape sampler with readout in "coefficient of haze" units is also more sensitive to particles in the respirable size range than the high-volume sampler, and thus one such instrument will also be installed and operated continuously at the same point as the integrating nephelometer. This EPA approved device (for which, interestingly, no corresponding Federal Ambient Air Quality Standard exists) provides hourly data continuously, and its measurements are also an indicator of the soiling effects of air pollution, an important aesthetic factor.

Size fractionation of suspended particulates will be performed on samples taken on one day each quarter in order to better quantify the continuous measurements of the integrating nephelometer and the AISI tape sampler. Because of the expected low particulate mass concentrations, sampling over 24 hours or more will probably be necessary in order to obtain sufficient mass in some of the size ranges. Thus diurnal variability in size distribution cannot be assessed from these samples, although estimates can be made using the information from the other instruments.

Elemental analysis of the material collected on the high-volume filters will be carried out on quarterly composites of the filter samples to determine the current concentrations in the ambient air of such trace elements as lead and beryllium, for which health effects exist. Vehicular operation in the lease area can be a source of atmospheric lead in the future.

Filter samples will also be analyzed quarterly for polynuclear aromatic compounds. Because of recent concern about possible carcinogenic emissions associated with oil shale processing, such analyses will establish current levels of this type of organic matter.

Two instrument technicians, experienced in the operation and maintenance of equipment in the field, will reside near the lease area at all times during the baseline study. They will regularly inspect and service all sampling and data collection equipment in accordance with an established written procedure, and will perform regularly scheduled extra tasks including high volume sampler filter changing, photography for visibility evaluation, collection and special handling of filters for trace metals and polynuclear aromatic compound analyses, and collection of size fractionated suspended particulate samples. These technicians will be provided with a four-wheel drive vehicle to enable them to perform their duties in snow and rain, with only rare occurrences of extremely inclement weather (during which air quality would not be very good, anyway) presenting a bar to regular servicing.

b. Equipment

The choice of equipment for the baseline study is crucial -- the air quality monitors must meet EPA requirements and all equipment must operate reliably enough to give correct data at least 90% of the time.

Each of the eight continuous air quality monitoring stations will consist of an instrumented dual-axle house trailer specifically designed and constructed by the lease operators for the particular demands of the baseline data acquisition program. Each trailer will be equipped with heating and air conditioning equipment to maintain the instruments at normal operating temperatures during all seasons of the year (the expected range in ambient temperatures being from -20°F to above 100°F) and will be parked in a fenced enclosure to reduce vandalism.

Primary power for each trailer will be commercial 115 VAC power as much as possible. In areas where it is not practical to run power lines, propane-powered motor generators will be used. Such generators will be installed at least 100' from the instrument trailers, in a generally downwind direction from the sensors. Tests will be performed to define errors in readings if the motor exhaust should be carried past the sampling tube; experience indicates these errors are not large and are easily detected if the wind direction is known.

Each trailer will also contain an internal motor generator which will automatically start in the event of failure of the primary power source. Internal installation will insure reliability even

after long dormancy or in severe weather; the proximity of the exhaust to the samplers will have to be considered, however. Automatic switches will also restart instruments, such as the gas chromatographs, which go into a "reset" mode upon a momentary interruption of electric power, as would occur during a change in power source. Some instruments, such as clocks, will have a standby battery power source to maintain accuracy during power outages or switching.

The air quality analyzer complement within each trailer will be identical. Specifically, each of the three full stations will contain:

1 automatic gas chromatograph with methanator (Beckman Instruments 6800), for analysis for CO, THC, CH_4 (and thus HC);

1 chemiluminescent (ethylene) analyzer (Monitor Laboratories 9410) for O_3;

1 chemiluminescent (ozone) analyzer (Monitor Laboratories 9440) for NO and NO_x (and thus NO_2);

1 automatic gas chromatograph (Tracor 270HA) for SO_2, H_2S, and total sulfur, and

1 high-volume sampler (General Metal GMWL-2000H) for particulates.

Each of these analyzers or samplers operates by means of the EPA defined reference method for analysis of a given pollutant, cr

meets the EPA standards for a method equivalent to the reference method. The partial stations will contain only the H_2S and SO_2 chromatograph and the high-volume sampler.

All of the gas samples will be taken through an insect-screened downward-facing sampling orifice above the trailer and some 14 feet above the ground level. A high flow rate glass sampling line will carry the samples into the trailer where manifolds wi will permit connections to the inlets of the analyzers. Excess samples not used for analysis, as well as residual byproducts of the analyses, will be vented at a location as remote as possible from the main inlet. Smoking in the area of the trailer will be prohibited, as will vehicle operation (except when necessary to carry heavy equipment to the trailer).

Redundant recording of data will be provided to help assure the required 90% data reliability. The primary recording system will be a digital data acquisition system with punched paper tape output. This system will sample all analyzers at 6-minute intervals. A crystal-controlled clock will provide a time record at each sampling, and is provided with a battery backup so that, should electric power be lost and then restored, the correct time of sample acquisition will always be recorded. A multipoint printing recorder will also record all channels as a backup in case of data acquisition system failure.

One of the trailers will contain, in addition to the normal instrements, an integrating nephelometer (Meteorology Research 1550) and an AISI paper tape sampler (Wallace Fisher 2500).

Other equipment available for periodic use will include a high-volume cascade impactor (Andersen 2000) for particulate size distribution measurement and two still cameras (one with color film, the other with black-and-white film) for visibility recording.

In addition to the eight trailers, a ninth system identical to the four full stations will be installed in a 4-wheel drive truck. This unit will be used for special studies as described earlier, can serve as a standby system during breakdown or shutdown of one of the fixed stations, and can be cannibalized for analyzers or parts to quickly restore a malfunctioning station to operation.

Calibration of all of the gas analyzers will be referenced to EPA approved calibration standards, either by actual calibration of span gases or analyzers by EPA or through independent laboratory calibration under EPA observation or concurrence. Secondary calibration standards, in the form of span and zero gases for CO THC, and CH_4, permeation tubes for SO_2, span gas and dilutes for NO, and ozone generator for O_3 (and NO_2 oxidation of NO), will be maintained on-site to permit periodic checks of instrument calibration and to allow recalibration of any analyzer which has required servicing which could have affected its calibration. Calibration of recorders and the digital acquisition system will be carried out against appropriate NBS traceable voltage standards, and the high-volume sampler flow rate will be calibrated using an appropriate pressure measurement standard.

The frequency of calibration will vary with the type of instrument, ranging from automatic calibration checks once per 24 hours to manual dynamic calibrations at maximum intervals of once per 3 months. Guidelines presented in the EPA document series, "Guidelines for Development of a Quality Assurance Program" will be followed, and calibrations will be more frequent initially until a drift history for each instrument has been established.

Each station will be able to operate unattended for at least two weeks, except for the high-volume sampler which requires a filter change once every 6 days. Thus, although servicing at 3-day intervals (with greater frequency initially) is envisaged, data acquisition would continue even though unusually severe weather might prevent regular maintenance for a short period. Standard high-volume sampling schedules allow "make-up" days, so that a sampling day missed for such reasons would not impact the 90% reliability limit.

After the baseline study is completed, the same instrumentation will be used on-site for the air quality monitoring system required during plant development and operation.

c. Monitoring Sites

A map (Figure 4) showing the location of each monitoring site is contained in the pocket at the back of this document. Twelve aerometric sites are shown -- sites 1 through 8 contain air monitoring and meteorological equipment, while sites 9 through 12 are purely meteorological stations. The rationale behind each air monitoring site location is presented here and its equipment is described. Only air pollution is considered here -- meteorology is discussed separately later.

Site 1 - Located near the White River, well west of the lease tracts, this is the ultimate receptor site for emissions from both tracts under stable drainage conditions and is a background site during periods when the prevailing westerly flows dominate the local air motion. A partial (i.e., only SO_2, H_2S, and particulates) air quality station will be established here.

Site 2 - This is a likely candidate for the point of maximum concentration for most reasonable choice of plant location in Tract U-a under conditions of low dispersion. A complete station will be established here.

Site 3 - Another possible high concentration point, this complete station will also assess the present daytime effects of the activities in the Bonanza area (and those for the north) on pollutant levels in the tracts.

Site 4 - This partial station is a background station during most nights, becoming a receptor station during daytime upslope or westerly flows.

Site 5 - This partial station would measure drainage from Tract U-b into the White River when plant construction and operation takes place. Now it serves as another receptor for emissions from Bonanza at times, as well as one indicator of the effects of highway 45.

Site 6 - This full station in Tract U-b is the equivalent of Site 2 in U-a, and also observes drainage flows along the Evacuation Creek channel. The integrating nephelometer, AISI tape sampler, and high-volume cascade impactor will be installed here.

Site 7 - This partial station to the northeast of the tracts is equivalent to Site 1, except that for it the probable day and night roles are reversed.

Site 8 - A partial station here observes the confluence of two "highways", is a receptor downwind of the tracts during most days, and serves as an alternate background station at other times.

A site location is not given for the ninth air quality station, which will be used in multiple locations during the study.

d. Analysis

The air quality data obtained during the baseline study will be mainly in the form of punched paper tape with backup strip chart recordings. In order to insure that all data is not lost by accident, both of these records will not be shipped from the site at the same time. Other data will be in the form of undeveloped film, and as particulate samples on filters or on impactor collection media. Because of the absence of redundancy in these, they will only be transported by a courier.

Initial processing of the paper tapes will be by computer for the purpose of tabulation of hourly averages of all gas concentrations, and comparison with all relevant ambient air quality standards. Categorization of data by meteorological regimes will also be carried out.

The high-volume filters will be weighed by an analytical laboratory to determine particulate mass. (The blank filters will have been weighed before use, also.) A composite of samples for each quarter will be analyzed for lead (by atomic absorption analysis) and for other trace metals (by neutron activation analysis or other appropriate techniques). Some filters, specially handled to prevent oxidation of the sample, will be chemically analyzed for polynuclear aromatics at a frequency of once each quarter.

The ultimate use of the data thus acquired will be two-fold. First, it will provide a detailed record of the current air qualtiy situation in the lease area. Second, it will provide a base (along with the meteorological data) for assessment of future plant impact.

For the baseline application all the air quality data will be categorized by meteorological regimes, related to air quality standards, and probable current source areas identified. The significance of the measurements of visibility, particle size distribution, soiling, trace metals, and polynuclear aromatics will be assessed and related to the same source and meteorological considerations. Areas of doubt will be resolved and, where feasible, extra experimentation will be performed to resolve any significant uncertainties in the interpretation of the data.

For forecasting and impact assessment, the current data serves as a reference base from which modeling can begin. Adjustment of background values due to sources external to the tracts will have to be made, considering expected growth and changes in their emissions. Some of these, e.g., Bonanza, are likely to be strongly influenced by plant development and operation. The emissions from others, such as Vernal, are more likely to be more independent of the plant.

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Because of the complexity of the terrain in the lease tracts area, computer modeling of air pollutant transport and diffusion is expected to be quite difficult. The various factors affecting dispersion, including air flow streamlines and turbulence levels will have to be defined in considerable detail. These, in turn, are governed by the synoptic meteorological situation, by solar heating, and by topography. Details of the methods used to acquire and process this information on the dispersive properties of the atmosphere is presented below in the discussion on meteorology. Once they are defined with adequate resolution, the modeling of air quality impact can proceed.

A variety of developed computer models, tailored for the specific conditions at the site, will be used. Standard plume rise formuals, coupled with developed rational plume dispersion models will be used for effluent emissions from stacks. Diffusion of lower height emissions, such as fugitive dust and emissions from motorized equipment and vehicles, will be handled by appropriate point or area source models in which the effects of surface roughness are entered. The photochemical reactions occuring in parcels of air containing emissions from the plant will also be modeled, although photochemistry is unlikely to be a problem in this area.

All of these modeling approaches will be exercised for a variety of meteorological conditions, with particular emphasis on stagnant conditions in valleys and with consideration of the complexities introduced by drainage flows in the complex topography there. A number of likely plant sites will be considered to assess the significance of alternative locations and to assist in selection of the final plant location.

2. METEOROLOGY

The complex terrain in the lease area has a significant influence on those meteorological factors related to air pollution dispersion. The topography varies in elevation from 4800' above sea level at the White River to 5900' just S of the tracts, is mostly between 5200' and 5600', and has many gentle hills and a few very sharp ravines. Significantly higher terrain is about 40 miles away to the south, and at greater distances to the west and east.

The region has little precipitation -- about 9" per year, with peaks in June and October. Some snow, typically a few inches, accumulates occasionally in the winter. Both summer and winter can be expected often to have very light winds, and fogs are common in winter. Below about 5600' one can anticipate nocturnal inversions winter and summer, which inhibit effluent dispersion. The complex topography will result in complex nocturnal drainage flows below this height. Except for the very light wind cases, the terrain roughness can be expected to yield moderate or strong turbulence and hence moderate or strong effluent dispersion. The height of effluent release (or rather, effective stack height) will have a large effect on surface concentrations of pollutants from local sources.

The details of the mesoscale/microscale mean flows and turbulence for such terrain are not established with acceptable certainty. Also, climatological data for the specific area do not exist, although six hourly winds are available from Green River and Roosevelt. The nearest radiosonde station is at Grand Junction, but because of topographic influences the winds below about 8000' above sea level cannot be related closely to the Grand Junction winds. The next nearest radiosonde at Salt Lake City is of minimal use here because of its remoteness.

a. Methodology

The a-proach to the measurement of meteorology is philosophically similar to that of the air quality measurements, with some continuous moniotring of meteorological factors for the entire 2-year period, supplemented by measurements and experiments designed to answer certain crucial questions concerning air flow and turbulence in the lease area.

Continuous measurements will be made by two instrumented 100 ft. towers, located at two probable points of high pollutant concentration, and sharing the data facilities in the air quality trailers there. Instrumentation on these towers will monitor wind speed and direction at 6 feet above ground level, and at 30 feet and 100 feet. Temperature will be measured at 30 feet and at 100 feet. The lease requires that humidity also be measured at ground level, 30 feet, and 100 feet. Since there is no clear reason for this redundance, permission to use only one humidity sensor on each tower, at 30 feet above the ground, is requested. These measurements will give indications of low level wind shear and of surface-based atmospheric stability.

To further define details of the low level airflow, an anemometer on a 30 foot m~~e~~ast will be installed at each of the other six air quality station sites to record wind speed and direction. In addition, frou battery-operated weather stations will be sited at key areas remote form the permanent sites to help describe slow features.

These routine meteorology and air quality observations are an expanded version of those needed for meeting regulations and describing baseline air quality. They also serve as one input to the determination of the manner in which the atmosphere will disperse any pollutants caused directly or indirectly by the shale oil operation. For making such dispersion predictions, and hence impact predictions, predictive models based on appropriate observations must be used. Such models are sufficiently developed so that they can be used reliably if turbulence and mean flow fields can first be ascertained, hence the meteorological program must be concerned with such measurements also.

Turbulence is a key factor in the analysis of dispersion, thus its measurement by anemometer and vertically oriented propeller is planned at the tops of the two 100' towers and at the highest

altitude permanent station. Because of the effects of temperature on drainage flows, this highest station will also monitor temperature.

Continuous monitoring of dispersive characteristics at greater heights above ground, particularly well above the mountain tops, is also needed. Construction of a tower high enough for this purpose is not practical, thus the use of acoustic echo sounding equipment is envisaged. Such instrumentation provides a continuous record of atmospheric structure up to 3000 feet above its antenna. In conjunction with the Grand Junction radiosonde data it will provide necessary information on upper air conditions above the lease tracts.

The mean flow and turbulence fields of importance include the region well above where the fixed measurement system operates -- up to 2 km above the ground. To some extent the characteristics of this region can be estimated with adequate accuracy from the fixed station system and the soundings and upper air maps available from the National Weather Service, but some supplementary measurements are necessary.

Furing two periods within the first study year, field studies of about two weeks duration each will be performed to study atmospheric dispersion in the tracts in detail. These tests will consist of smoke or oil fog releases from balloons at various heights above the ground, at dawn to illuminate drainage flows and in early afternoon to show valley wind effects. Photography and probing (where safe) by an aircraft equipped with an integrating nephelometer will define plume dispersion. Pibal launches and aircraft soundings three times a day will give details of wind, temperature, and turbulence up to 2 km (6000 feet) above ground level above several locations in the area.

In support of the water resources portion of this program, rainfall will be monitored at six locations in the tracts area.* Snowfall, per se, will not be measured continuously, but the water content of melted snow will be recorded. Samples of precipitation will be collected continuously for laboratory analysis.

The meteorological program will dovetail with the air quality measurements, and will share the same field personnel and data equipment. These aspects of operation have already been described earlier and thus will not be repeated here. A log of meteorological observations will be maintained by the technicians to record depth of snow, degree and type of cloud cover, and any other observations (e.g., blowing snow) which would be of use for the purposes of this program.

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*The USGS is presently reviewing the requirements for precipitation monitoring in this area. The final number and placement of rain gauges in the tracts may be changed upon completion of that review.

b. Sites and Equipment

Each of the eight air monitoring sites (Sites 1 through 8) will contain some meteorological equipment. In addition, four additional sites (labeled Sites 9 through 12) will be equipped solely with anemometers for local flow measurements. The equipment at each site, and some description of its use at each location follows:

Site 1 - An anemometer on a 10 m (33') tower records drainage flows along the river channel, and a heated rain gauge monitors precipitation.

Site 2 - A 100' tower here is equipped to measure wind at 6', 30', and 100', temperature at 30' and 100', and humidity at 30'. Lateral and vertical turbulence are measured at 100'. Both solar radiation and precipitation are recorded continuously. This site thus records the general meteorological situation in tract U-a.

3 levels

Site 3 - An anemometer on a 10 m tower monitors airflow between the tracts and Bonanza, and records precipitation.

Site 4 - An anemometer and temperature sensor on a 10 m tower record upslope winds, drainage flows, and turbulence, at this highest level station. Precipitation is also recorded.

Site 5 - Equipment and function same as Site 1.

Site 6 - Equipment the same as Site 2, this station monitors general conditions in Tract U-b. An acoustic echo sounder will also be installed here.

Site 7 - Wind speed and direction at 10 m will be measured here.

Site 8 - Equipped the same as Site 7, this location will monitor airflows along the higher ground east of the tracts.

Site 9 - An anemometer here observes the division of airflow over the ridge dividing Tract U-a.

Site 10 - Flows within the White River channel near the junction with Southern Canyon are monitored by an anemometer here.

Site 11 - Flows along this higher terrain between the two tracts are sensed by an anemometer installed here.

Site 12 - An anemometer here records flows along Evacuation Creek above the tracts.

The equipment selected for the meteorology study must meet even greater reliability requirements (95%) than the air quality instruments. Fortunately, meteorological sensors are inherently

rugged and reliable, and the more likely areas of non-reliability are electrical power and recording. Since redundancy has been provided in all of the power and recording systems in the trailers within which both the air quality analyzers and meteorological system electronics are situated, the 95% reliability factor should not present a problem.

On the 100' and 30' towers, the anemometers will be of the cup and vane type (Meteorology Research Inc. 1022), with threshold below 1 mph, response distance less than 5 ft, and proper (0.4 to 0.6) vane damping ratio. These characteristics make them suitable for turbulence measurement also, and the direction vanes pm tje twp 1--' level anemometers (and the anemometer at Site 4) will be coupled to sigma meters to compute the root mean-square lateral dispersion. Vertical dispersion, computed from vertically oriented propellers, will also be measured at these points.

The temperature sensors on the towers, of the thermistor type, will be housed in proper radiation shields (R.M. Young 43404). The humidity measurements will be continuously made by electronic measurement of dew point (EG&G 880 or equivalent) and solar radiation measurements will be made by standard sensors. Recording of all these parameters will be continuous on the multipoint recorders, and running means will be processed for recording on the digital data system.

The separate battery-powered weather stations will be of a well proven wind vane and cup type (Meteorology Research Inc. 1071 or Climatronics EWS). Electrically heated rain gauges (Meteorology Research Inc. 370) of the tipping bucket type with collector bottles for the effluent, will be used on the roofs of 6 of the trailers.

The meteorological sensors require calibration and maintenance less frequently than the air pollution analyzers, and they are also less easily accessible. Calibration of the anemometers before the study and once per year thereafter will suffice, while quarterly calibration of the humidity and temperature sensors is adequate. Calibration will be performed by appropriate testing laboratories. Operation of each unit will be checked at the same time that adjacent air quality analyzers are checked. The battery-operated weather stations require service only once per month, but weekly checks will be made if possible.

The acoustic sounder (AeroVironment 300) requires infrequent service, except for occasional operational checks, and no calibration is required. Being situated in one of the trailers, it will receive frequent observation.

During the two field studies of diffusion, turbulence will be measured from the aircraft by means of an inertial subrange turbulence measurement system (Meteorology Research UITS) which measures turbulence independent of aircraft speed. Temperature

will be measured by a thermistor probe, and both parameters will be recorded on board the aircraft on a strip chart recorder. Pibal tracking, by double theodolite, will also be performed at several sites.

All meteorological instrument specifications and exposures will meet NOAA, WMO (World Meteorological Organization), and EPA criteria whenever such criteria are relevant. In a few cases where low-level flows are of interest, deviation from the exposure criteria will be justified.

c. Analysis

Processing of meteorological data will follow the same procedures as described before for the air quality data. Meteorological regimes will be defined and the data will be classified on the basis of these regimes to determine frequency of occurence. These regimes will be correlated with radiosonde-derived climatological statistics at the nearest National Weather Service stations. In this manner the studies for the tracts can be assembled into statistical presentations based on long-term records, and the chance of the possibility that measurements during the two years were not representative of long-term trends can be assessed.

The meteorological data will be analyzed to provide (1) assessments of the terrain induced flows and turbulence, (2) statistics on stability categories and winds aloft, and (3) statistics on probable adverse air pollution conditions (low winds, strong stability).

For inputs to the air pollution diffusion modeling, a set of flow categories will be developed, related to the regimes just mentioned. The flow categories will include seasonal and diurnal variations, and will be related to winds aloft, and to stability aloft (which identifies the connecting link to flows aloft). The field observations, especially the complete ones during the flow/diffusion test periods, will put the modeling on a sound footing.

Precipitation measurements will be used for the water resources studies, and were discussed in that section of this document, as well as for interpretation of the radiation measurements discussed below.

Not in water resources studies section!

3. NOISE

Noise conditions in the tract areas are expected to be quite low except for the sounds of flowing water and wind noise at certain times. Athropogenic noise comes from the limited traffic on dirt roads in the area, and from men and sheep in the spring and fall. The monitoring program, with its high volume samplers and motor generators will introduce some noise into the area.

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In order to assess background noise levels and to determine the local propagation characteristics of the newly introduced noise sources, as functions of local meteorology, a two-phase noise monitoring program will be carried out during the two-year baseline study.

One phase, concerned with the background levels, will consist of 48 hours of continuous noise monitoring once each quarter at each of 3 sites represetative of different conditons -- in the White River channel, in a canyon (e.g., Evacuation Creek), and on a ridge removed from identifiable sources.

The second phase will assess the impact of the baseline monitoring program by measuring the noise profiles around each noise-significant monitoring site out to distances where their noise is indistinguishable from the background. These surveys will be made periodically both day and night to cover as many source strengths and propagation conditions as possible.

Measurements will be made with a general purpose sound level meter (Bruel and Kjaer 2205) which meets International Electro technical Commission recommendation R123. Readings will be made with an omnidirectional sensing head with a windscreen and will be filtered by an A-weighted (human aural response equivalent) filter for readings in dBA.

4. RADIATION

Although ambient radiation levels in the area are not known, some nearby regions manifest some radioactive activity and some mined materials show even higher levels of radioactivity. Since retorted shale may be disposed of by landfill in the area when mining begins, measurement of current radiation levels is needed to assess baseline conditions before shale development.

To do this, continuous monitoring of gamma-radiation will be carried out for the entire two years at one point in the area. The monitoring location will be located at the point of greatest radiation, chosen on the basis of a radiation survey of the two tracts. This continuous monitoring will delineate the combination of both locally generated surface radiation and the meteorologically affected airborne radiation levels.

The tracts will be resurveyed quarterly under various meteorological conditions to assess spatial variablity in various atmospheric conditions. Vertical surveys along the towers will separate the airborne and surface caused contributions.

If the monitoring indicates levels anywhere in the tract area well in excess of the expected 12-16 μr levels,then air sampling to determine the presence of radon and other gaseous radium daughters will be performed. The need for this step is at present considered highly unlikely, however.

Measurements will be made with an ionization chamber and recorder, which is sensitive enough for these low radiation levels. Except for the vertical surveys, the measurements will be made at the accepted level of 1 m above the ground.

Analysis of the ambient data, along with the radioactivity analyses of core samples, will permit assessment of future radiation impact of mining activities.

C. BIOLOGICAL RESOURCES

1. VEGETATION

The vegetation of the lease area represents a major expression of the productivity of the site. Several aspects of vegetation, when understood, provide a key to the existence of domestic livestock and wild herbivors which depend on plant growth. The abundance, diversity, seasonality and patterns of growth and development are necessary objects of study in order to characterize the vegetation as it exists during the baseline study period. Other studies of the areas depend on a clear understanding of the distribution of plants over the lease area and adjacent lands. The soil survey and vegetation map produced in the early phases of the study will be important tools for further studies such as surface hydrology meteorology, facilities location and wildlife migration patterns.

Standard techniques developed in the International Biological Program Desert Biome study will be followed. Inasmuch as there are many similarities between this site and the Curlew Valley desert site in Northwestern Utah, the methods will be followed. Another advantage of using similar methods will be the availability of a computer program to process and summarize the information collected from the field.

Parameters Measured

General plant distribution patterns observed in aerial photographs and on-site surveys will be used to develop a vegetation map of each tract and adjacent lands.

The information to be collected from plots established in the identified vegetative types include:

a. plant species (many annual plants can be identified only at appropriate seasons of growth).

b. plant density

c. plant height

d. plant cover

e. basal area

f. phenology (observed developmental stages of plant growth)

g. litter

h. roots (limited observations sufficient to characterize rooting habits).

Some environmental factors will be measured in relation to vegetation. These will usually be done by other disciplines but the results will be interpreted in relation to plant growth and ecosystem functioning. Two measures in particular will be considered:

a. Soil moisture

b. Soil and air temperature

Methodology

After establishing a vegetation type map of the study area from aerial photographs, surface observations and consultations with soil scientists working on the site, a statistically adequate number of 2 x 2 meter quadrats will be located on each vegetation type. A 1 x 1 meter quadrat to study grasses and annual herbs will be nested within the larger quadrat. From ex-

perience of the Curlew Valley Site validation studies, 10 to 20 quadrats per vegetation type may be adequate to sample the vegetation. The actual number of quadrats required can only be determined by making observations on-site and based on natural variation, adjusting the number of quadrats accordingly.

All measurements will be made according to species at appropriate seasons (fall for perennial plants and spring for annuals). Data will consist of simple measurements of plant dimensions, i.e. height, diameter, cover, and distance. Some ocular estimates will be used in the case of plant cover and phenology. Where occular estimates are used actual measures will serve as references.

Species determinations will follow established botanical keys and nomenclature for the region.

Reference herbarium specimens will be collected, prepared and mounted. They will be deposited in the Intermountain Herbarium. Other specimens will be retained as reference collection at the study site.

Data will be recorded in the same manner as used for IBP Desert Biome data system and submitted to the USU computer center for processing and summarization.

Ground truth plots will be established for reference purposes for routine aerial photography - remote sensing. These plots will be clearly outlined and the species composition determined

and mapped. Species and phenology observations will be made concurrent with photographic flights.

Program Applicability

Establishment of a record of plant occurrence and conditions prior to any activities relative to oil shale development will provide a reference for future questions, i.e. whether significant changes have or have not been induced. Many vegetation characteristics are sensitive to environmental impacts and would thus serve as an indicator of changed environment.

Work Schedule

1974

Preliminary survey of site and existing information maps.	July 1 - July 15
Development of vegetation map.	July 1 - Aug. 1
Establishment of sample plots, develop record forms.	Aug. 1 - Sept. 1
Record data on plots.	Sept. 1 - Oct. 15
Process data and samples.	Oct. 15 - Nov. 1
Prepare report.	Nov. 1 - Nov. 15

1975

Record data on Spring site and phenology	April - May
Process data	May 1 - 15

Potential of Scientific Activities for Disturbance

Little disturbance to existing vegetation is expected because of the non-consumptive measurements used. Care will be exercised in use of vehicles to remain on established roads and trails where ever possible.

PRODUCTIVITY

Production of plant material is an important aspect of a given ecosystem. Generally the amount of plant biomass produced reflects the favorable aspects of the soil, weather and impacts of related animal life in any growing season. Assessment of productivity may be very detailed such as above ground plant growth, roots, vertebrate and invertebrate animals, and even micro organisms. However, for the purposes of establishing a baseline of site productivity for the oil shale lease tracts, assessment of above ground plant production will provide an index of the existing conditions prior to any development. Great seasonal fluctuations occur from year to year with regard to total plant production. Perennial shrubs and herbs do not vary as much as annual grasses and herbs. To augment the observations made during the study period, records of the Bureau of Land Management will be reviewed and relevant portions included as a part of the baseline study. Past grazing use records and condition and trend studies will be assessed to provide a measure of productivity for the various vegetation and soil units within the lease areas and adjacent lands.

Parameters Measured

The main parameter that will be measured is the current year's growth of above-ground plant parts separated according to species or groups of species such as shrub, herb and grass. Additionally, samples of surface litter will be sampled and

when possible, separated by current growth and previous years' growth.

The difficulty of obtaining plant growth for an entire season is recognized because annual species will require sampling at the end of the spring growing season while the perennial plants will require a sampling period at the end of the summer. Two sampling periods will thus be necessary.

Below-ground plant parts and non-vascular plants will not be sampled but field notes will be taken on their abundance and general occurrence.

Methodology

From vegetation maps prepared from aerial photographs and on-site surveys of soils and plant communities a statistically adequate number of production sampling plots will be established. These plots will be placed in the major plant communities in locations observed to be most representative of the areas sampled.

Sampling plots will be 2 x 2 meter quadrats for shrubs and nested 1 x 1 meter quadrats for annual grasses and herbs and litter. Data to be obtained will consist of:

a. current year's growth of shrubs and small trees.
b. current production of above ground yield of perennial herbs.
c. total production of above-ground yield of annual grasses and forbs.
d. surface litter.

Plant samples will be collected separately by species or groups of species; clipped, bagged, dried and weighed. To leave a permanent location for the yield plots for future reference, metal rod plot markers will be driven into the ground on two corners.

Program Applicability

Production of living matter is highly dependent upon the favorability of the environment for plant and animal growth and reproduction. Any unfavorable impact on the quality of the air, soil or water can cause temporary or permanent changes in the production of plant material and thus alter food chains and the general functioning of the ecosystem. Productivity is the basis for herbivore populations, both domestic and wild.

Several studies that will be required in the future will depend to a high degree on information generated about the vegetation, seasonal patterns of growth and the relationship of plant growth to environmental factors. One of the most important of such studies is that of revegetating disturbed areas and spent shale. Wildlife migration patterns is another area of study that will depend upon vegetation information generated in the baseline study.

To augment and extend the usefulness of data collected during the baseline study, the range condition and grazing use records of BLM will be correlated with study data to gain a long time frame of reference.

Work Schedule

1974

On-site survey, review of records, preparation of vegetation map.	June 15 - July 30
Location of production plots.	Aug. 1 - Aug. 30
Sampling of production of shrubs, perennial herbs, litter.	Sept. 1 - Oct. 1
Treatment of data and summary.	Oct. 1 - Oct. 15

1975

Sampling production of annual plant species (depends on weather).	April - May
Treatment of data and writing report.	May 15 - May 30

Potential of Scientific Activities for Disturbance, etc.

The sampling of plant productivity will remove current year's growth from shrubs and herbs but is not expected to leave any permanent effects. The number of plants sampled of annual species will not produce any significant effects because of the small areas sampled and the normally quick disappearance of annual litter in this ecosystem.

Care will be taken to locate study plots in obscure sites. Vehicle traffic to service the plots will be limited to established trails and roads. Permanent metal rod plot markers will be marked for easy location.

2. WILDLIFE

Since the wildlife components of the area are dependent upon the existing vegetation, the ecosystem approach will be employed in all data collection and analysis. For most plants and animals the inventory will consists of biomass determinations per hectare per species or taxon. The exceptions are nonvascular plants and microbes where measurements of activity are more meaningful than biomass determinations. Those components of the ecosystem that move in and out of the sites will be monitored and impacts on them assessed. Deer, possibly elk and wild horses, cattle, sheep, jackrabbits, their predators, some birds and other species are the important components in this respect. A similar situation exists with invertebrates, because it is really impossible to sample them, during certain stages of their life cycle. Hence their inventory must be conducted through an entire year.

Prior to any biological field studies, collection and trap permits will be obtained from permitting agencies. Biological societies and organizations (e.g., Audubon Society, National Wildlife Federation, American Fisheries Society, etc.), as well as appropriate federal and state agencies, will be notified of the conduct of the study in order to coordinate the exchange of collection data and biological information.

a. Terrestrial Vertebrates

The objective of this part of the survey is to generate a species inventory of the terrestrial vertebrates on the sites and to determine the density and distribution of as many of these species as possible. These data, together with information about other components of the ecosystem, will be used to develop a general statement of the relationship between the terrestrial vertebrates and other elements of the ecosystem.

The methods used to meet the objective are a group of procedures designed to sample the various types of vertebrates that are likely to be on the sites. Most of the sampling techniques are the same as or similar to those used by the Desert Biome Program on their validation sites. This program, which is a large and well established endeavor supported by the National Science Foundation, has a great deal of experience in sampling desert communities. It has developed data acquisition, storage, and retrieval systems that fit the requirements of the current survey. The use of these designs and systems where possible will facilitate the survey of the various vertebrate groups.

Rodents

Parameters:

The dependent variables are species, numbers, sex, age (where possible), nipple condition, testicular condition, and body weight. The independent variables are habitat type and time of year.

Methodology:

The rodents will be sampled with two techniques. Both will employ 3x3x10 inch Sherman live traps baited with rolled oats and peanut butter. The first technique will involve placing the traps on a 12x12 grid with 15 yard centers (144 traps). The traps will be set several hours before sunset and checked several hours after sunrise. The length of time before and after will vary according to the number of transects being run on any given night and the time required to set the traps. The procedure will be repeated in the same location for five consecutive days. The technique will be applied to each of the three major vegetation types and will be altered as necessary based upon the topography in the area. Each transect will be run twice a year at the beginning and at the end of the reproductive season.

All animals will be toe-clipped for identification, removing not more than one toe from each front foot and two toes from each hind foot. Data, including species, sex, age, sexual condition, and weight in grams will be recorded in the field on computer-compatible forms. Age determinations will be subjective judgements based upon size, weight and appearance, separating animals into three age classes, juvenile, subadult and adult.

The data analysis will follow that developed by Robert Anderson at Utah State University. The most critical problem in the analysis is to determine the area which is effectively trapped

by the procedure. This determination will be made by the application of a multiple regression formula to the method described by Jennrich and Turner (1969). For a more detailed discussion of the analytical procedures and their rationale see Balph,(1973).

The second technique will employ transects of 12 traps placed 15 yards apart. These will be run at 90° from existing roads throughout the sites and in some peripheral areas. They will incorporate different vegetation types, slopes, and aspects. About 60 transects will be conducted bimonthly. Each transect will be operated for 1 day at a specific location and thus will yield only an index to density; however, the data will be related to information obtained the first day using the grid-trapping technique, in an attempt to arrive at a crude estimate of rodent numbers.

Rodents will be collected in limited numbers and stomach content analysis made to determine food habits. This information will be related to studies presently being done in the Desert Biome. Program and to available literature to determine impact on seed reserves.

Rationale:

There are two sources of variation in any field sampling procedure: the variation caused by technique bias and the variation which actually exists in the population through space and time. Since the sites are relatively large and diverse, the latter

source of variation is likely to be more important than the former source. The techniques for the vertebrate survey, especially those to be used on rodents, were selected with this point in mind. The grid trapping will give an adequate estimate for that area in which it is located. However, constraints on time and effort will not permit adequate replication nor adequate coverage of the entire area. Thus the transects must be relied upon for replication and for extended coverage, even though they are only indices to density.

Rodents play two important roles in a desert ecosystem. The first of these is in forming a food base for most of the mammalian and avian carnivores. This is especially the case when there are few jackrabbits. The second role, one which is not firmly established, is that of influencing the abundance and distribution of seed reserves.

Bats will also be studied on the sites. The species will be trapped, identified and released by using mist nets. The netting will occur in the early night hours during peaks of activity. Netting will occur along stream bottoms and in other areas where activity is the highest. Estimation on population densities and extent of activities will be determined. Exploratory searches of caves and other areas on the site that may be used for daytime rest areas will also be searched . To determine activities and extent of movements all bats caught will be marked by tagging or clipping and released for recapture.

b. Diurnal Mammals

Parameters:

The dependent variables are species designations, numbers, sex, and age (where possible). The independent variables are time of year and vegetation type.

Methodology:

Diurnal mammals will be sampled by flushing transects described by Gross (1967). The number of animals of each species observed and the distance at which they are seen will be recorded as the observer walks the transects. About 10 miles of transects will be walked bimonthly through each of three major vegetation types.

To augment these data, animal sign transects will be walked to look for and to record signs of activities such as scats, dens, burrows, and tracks. About 5 miles of these transects will be walked bimonthly in each of the three major vegetation types.

Rationale :

Flushing transects are most suitable for species such as jackrabbits and cottontails. They tend to underestimate to varying degrees the populations of those mammals which are fossorial in their habits or which do not flush readily. The animal sign transects should assist here. Even though the data from sign transects will be qualitative, they may be important in expanding species lists and may be used as a rough index to the density

of those animals which are not subject to other sampling procedures.

The larger more conspicuous mammals including deer, horses, cattle, sheep, coyotes, bobcats, mountain lions and possibly elk, should any be on the side, will be censused in the winter when snow cover is good. This will be done after winter migration by game species such as deer is completed and predators have moved into the area. The censusing will be done from natural vantage points on site and by using a helicopter with observers experienced in making counts of this type. Movements of animals will also be determined by following trails in the snow. Counts on larger raptors such as golden eagles will be included during these flights.

Seasonal movements of deer, determined by trapping and branding operations will be studied by wildlife specialists of the Utah Division of Wildlife Resources. Standard feed-in single animal type traps will be used employing typical baiting techniques. Traps will be set each evening and checked each morning for a period of time to be determined by the success of the trapping operations. A representative sample of the herd based on aerial counts will be banded. Trapping and banding will be done during the winters of 1974-1975 and 1975-1976 and data from field sighting and hunter kills will be compiled. Extent of movements by deer wintering in the area and summering in other areas will be detailed.

c. Livestock

Parameters:

The variables are species, numbers, age (where possible), and the amount of time spent by the animals in each vegetation type within the sites.

Methodology:

Most of the information necessary for monitoring livestock use of the oil shale lease areas will be obtained from the Bureau of Land Management and from the grazing permittees. This will include kinds, numbers, age, and length of time in the general area. The remaining parameter, the proportion of time spent in each vegetation type within the study area will be determined by the transects conducted for diurnal mammals.

With this basic information and with data obtained from the vegetation survey, much can be inferred about the livestock. The impact of cattle, and perhaps with some modification of other grazing animals, on vegetation can be estimated with a grazing model developed by the Grassland Biome Program. The model has been validated and performs well (George Innis, pers. comm.).

Rationale:

Livestock generally are the most important herbivores in any area where they are maintained. Their impact on the vegetation

usually far exceeds that of any other group of organisms. It is therefore necessary to monitor livestock use on the sites and to access their impact on the other elements of the ecosystem. The methods described should accomplish this fairly well. The biomass of larger species of mammals can only be estimated. Observation on numbers, approximate size and body condition will be used to determine these figures.

d. Birds

Methodology:

The Emlen (1971) method of line transects, or a modified version of it, will be used to obtain estimates of absolute population densities of bird species. Transect counts will be made throughout the year in areas chosen to be representative of each major vegetation type. Sampling trips will be initiated one-half hour after sunrise and usually completed within two hours. An average of four 1-mile transects (only one transect can be covered per day) will probably be run in each of three major habitat types bimonthly. Identical transect routes crossing all vegetation types will be followed. This technique allows for more uniformity of transect counts between observers. Both right angle and radial distances will be determined for each bird detected on either side of the transect line. Detections will include sightings of any bird sitting on the plot or unseen vocalizing birds whose locations can be closely approximated. The transect strips will include observations laterally for a distance of up to 75m. Range finders will be used to accurately determine

distances of less than 30m. Supplementary records will be kept of all bird species seen on the sites, to cover rare or far-ranging species whose populations cannot be adequately assessed by a transect method. It should be feasible to make an absolute count of raptors during the nesting season.

Rationale:

The methods described should permit a determination of the avian species composition on the sites. In addition, they will provide an estimate of these species' temporal and spatial distribution and abundance. Although consumers such as birds have a smaller impact than do producers on the operation of a total ecosystem, birds may nevertheless exert a significant influence on insect and rodent populations (via predation) and on plants (via seed consumption or dispersal). The magnitude of this influence depends upon the bird species present and upon their population densities.

The total biomass of each species per site will be based on body weight of specimens collected. Most small birds will be collected with mist nets, but more elusive species will be collected by shooting. Birds will be weighed, sexed, aged, branded and released, while the sexually monomorphic species, not in breeding condition will be dissected to obtain this data.

e. Amphibians and Reptiles

Available literature on probably local amphibians and reptiles

will be researched for what is known of their feeding and reproductive behavior, migrations, and specific habitat requirements throughout their life cycle.

Parameters:

The species, sex (where possible), and body weight of all the reptiles and amphibians captured will be recorded as dependent variables. The independent variables are habitat type and time of year.

Methodology:

A standardized procedure for collecting amphibians is lacking. There are optimal conditions and methods, however, which maximize the number of organisms collected per man hour of effort expended.

Amphibians require water for successful breeding and can be found in greater number during or after a spring rain at night. Migrants such as the tiger salamander (Ambystoma tigrinum) that have overwintered in rodent burrows will be moving to quiet water to breed, usually from March to June. When all of the aforementioned conditions are present, a vehicle will be driven slowly along State Highway 45 from Watson to within 1/2 mile of Bonanza and on other roads on and around the project area. An observer will be watching for small objects on the road. Many of these will be migratiing salamanders, frogs and toads. They will be captured, identified, tagged by toe clipping recorded on an area map according to odometer check and released. Springs,

seeps and quiet pools will be sampled periodically during the spring months for egg clusters, larvae and ripe adults by trained observers with hand nets and waders.

The non-migrating Great Basin Spadefoot Toad (Scaphiopus intermountanus) may occur in the area. This toad appears soon after summer rains to breed, feed and reburrow. While on the surface, their chorusing makes them easy to locate.

The reptiles are going to be most active during the summer months when temperatures are higher. The lizards, active by day, can be approached and captured with a telescoping pole fitted with a slip-knotted noose on the end.

A lizard capture-recapture program will be conducted on 120 x 120 yard plots by walking 12 parallel transects, 15 yards apart. Captures will be toe-clipped and released. Such a capture-recapture method conducted over 5 consecutive days should be adequate (see Turner et al., 1969). The current plan is to conduct one of these transect grids in each of the three major vegetation types at the beginning and at the end of the reproductive season.

The second technique will be to walk a series of 120-yard transects at 90° from existing roads. The collection and analysis of these data will be as described for the similar techniques used on rodents. Snakes will be active day or night when the temperature is above 65° F. During the day snakes may

be seen on the site or found under rocks. Crowbars, heavy leather gloves, high-topped boots and pole snares will minimize the rattlesnake hazard. All rocks will be returned to their original positions to minimize habitat disturbances. Snakes often are found on asphalt roads at night, because asphalt absorbs more heat during the day than bare ground and a snake, dependent upon an external source of heat to maintain activity, may remain active longer into the night. This allows the snake to exploit the nocturnal mammal populations for food. Summer road running for snakes will be conducted in essentially the same manner as for amphibians. A snake stick will minimize the rattlesnake hazard. All non-venomous snakes will be catalogued and tagged by cutting small wedges of skin from the ventral scutes and recording scute number, counted forward from the anal scale. They will then be released. It should be noted that snakes are relatively rare in any habitat, and lack of sightings does not preclude their occurence.

Rationale:

Habitat preference, species population and distribution projections will be determined from the raw data and frequency of recapture as determined by the tagging system.

Stomach content analyses of common species will delineate their food preferences. These analyses will require the identification of plan seeds, insect parts and the bones of birds, mammals and reptiles. Only the minimum number of animals will be sacrificed

to obtain representative diets. Much of this information is available from existing available literature.

Threatened Wildlife

There are no known threatened amphibians or reptiles occurring in the project area.

Work Schedule

1974

Walk throughs will take place in July to become acquainted with the site. Sampling areas based upon habitat types and topography will be selected and transects chosen and marked. The actual inventory of species will begin in early August or as soon as permission is received to sample. The remainder of the year will be spent compiling data on non-migrant species and those species that winter in the area.

1975

During the year data compiling will continue and modification of sampling methods will be made to obtain more accurate data. The base line report will be submitted on March 1 and should be rather complete in relation to distribution and abundance of most species. Due to the migratory habits of some species and the inactivity of others during parts of the year the first complete base line report will not be completed until September. Once the sampling techniques are finalized they will be maintained for the duration of the year.

1976

The same sampling techniques will continue throughout 1976. At the termination of the program in 1976 voluminous data will have been compiled. The data will be sufficient to make a comprehensive statement in the final report. This report will show what terrestrial vertebrates occur on the site, approximate numbers and how they interrelate with the other components of the ecosystem.

f. Microbiological activity

The objective of microbial aspects of the survey is to estimate mean probable numbers of microorganisms in the soil and to gage their activity. The activity of microorganisms is extremely important in the detritus food chain and in mineral cycling. The proposed sampling program should estabish a base line for this very important segment of the ecosystem.

Parameters:

The dependent variables are aerobic bacteria numbers, streptomycete numbers, anaerobic bacteria numbers, fungal numbers, proteolytic activity, dehydrogenase activity, phosphate activity, nitrogen fixation, ammonification, and denitrification. The independent variables are microorganism type and time of year.

Methodology:

Bimonthly soil samples will be collected with an auger at the 0-3, 5-20, 40-50, 70-80, 110-130 cm depths. The number of samples

taken in each vegetation type will be determined empirically from the minimum number necessary for statistical uniformity. The samples will be placed in sterile plastic bags and stored at 3°C until they are processed.

Prior to analysis the sample is mixed thoroughly with a mortar and pestle.

The determination of microbial numbers will be 13 made by placing 1 g of each sample in a 250 ml screw-cap Erlenmeyer flask containing 99 ml sterile distilled water to give a 1:100 dilution. After vigorous shaking, further dilutions of 10^{-3}, 10^{-4}, 10^{-5} and/or 10^{-6}, as needed, will be made in screw-cap tubes containing 9 ml sterile distilled water. Five plates will be made for each dilution. Plates with 10^{-2} and 10^{-3} and 10^{-4} dilutions will be poured with Martin's Medium for the enumeration of fungi. Plates with 10^{-4}, 10^{-5}, and/or 10^{-6} dilutions will be poured with Soil Extract Agar for the enumeration of bacteria and streptomycetes.

After thorough mixing, the agar will be allowed to harden, and the plates incubated at 22 C. The plates will be stacked and inverted during incubation time. The fungal plates will be counted after 5 days, and the streptomycetes on the same plates between 7 and 14 days.

For microaerophilic plate counts, soil dilutions of 10^{-3} and 10^{-4} will be plated with Brewer's Anaerobic Agar (Difco). The

solidified plates will be placed upright in large desiccator jars. The desiccators will contain a small amount of 0.5M sulfuric acid to obtain a less than saturated water vapor atmosphere. The air in each dessicator will be replaced with nitrogen. This process will be repeated three times. After 14 days the plates will be removed and counted.

All microbial counts will be reported on an over-dry soil weight basis. The Curlew Valley validation site report of 1971 research RM 72-1 (Balph, 1972) also describes techniques which will be employed to measure soil respiration (p. 79), phosphatase activity (p. 79), proteolytic activity (p. 80), dehydrogenase activity (p. 81), soil pH (p. 81), ammonium nitrogen (p. 81), total nitrogen (p. 82) nitrate nitrogen (p. 82), nitrate nitrogen (p. 82), organic carbon (p. 82), and soil moisture content (p. 84). Nitrification potential will be measured by a percolation method, using a perfusion appartus as described by Collins and Sims (1956). Nitrate will be determined with the 4-methlumbelliferous method (Skujins, 1964).

Soil water potential will be measured using a Wescor, Inc., Model MJ55 psychrometric microvoltmeter with a Model C-51 Sample Chamber Psychrometer (Instruction Manual, C-51 sample Chamber Psychrometer, Wescor, Inc., Logan, Utah). The psychrometer will be callibrated according to Wiebe et al. (1971).

Work Schedule

It will take one year of bi-monthly sampling to establish a base line for microbiological activity. Monitoring will continue during the second year with an emphasis upon interactions among the microorganisms, vegetation and soil invertebrates

g. Terrestrial Invertebrates

Introduction and Objectives

Terrestrial invertebrates on the site can be expected to far outnumber vertebrates, both in numbers of species and individuals. Even in total biomass, they may exceed vertebrates, except during the periods of livestock grazing or driving. They will also be exceedingly pervasive in terms of ecological niches occupied and in their effects on other elements of the ecostystem. However, the great majority will fluctuate under limits of various biotic and abiotic checks and balances on the site and, without undue disturbance, may appear to be exerting little effect on the overall ecology. Nevertheless, their service, in such items as detritus breakdown, soil structure, pollination, and regulation of plant competition is vital to the functioning of the ecosystem.

Occasional outbreaks of defoliating lepidopterous (butterfly) for coleopterous (beetle) larvae or of Orthoptera (grasshoppers) may take place with or without undue disturbance, and these may sometimes be influenced by migration from other areas. Sucking forms such as mites (Acarina) and various hemipterous (lice a-

phids(insects will probably be abundant but may not cause noticeable damage unless they reach tremendous numbers. Mites, in particular, respond quickly to water stress in the plants, dust deposition on leaves, and any reduction in parasite level. They, and some of the insects that have exceptionally high reproductive potentials might be good indicators of disturbances brought by future activities.

Although the term "terrestrial invertebrates" is used here, it is expected that nearly all of the emphasis will be on arthropods. This is for two major reasons: 1) Among invertebrates, the relative importance of arthropods tends to increase under more arid conditions. 2) Expertise on sampling procedures, determination of taxa, and ecological activity is generally much more available for arthropods (and especially for insects) than for other invertebrates.

Insofar as possible and practical, the terrestrial arthropods of sites U-a and U-b and one or more coparable off-site check areas will be inventoried to provide information which can be integrated with the other elements of the biotic and abiotic studies of the ecosystems involved. This inventory will include a list of the taxa, and their distributions and densities on the sites and check areas.

Parameters

(1) List of Taxes

Based on an ongoing study of a similar nature in Curlew Valley, Utah, it appears that the number of species of insects alone will approach 1,000. Other macro-invertebrates could add several hundred species to the list. A collection will be made of all arthropods taken by the sampling methods outlined below as well as by other opportunistic collecting. These will be identified to species when possible; however, because authorities on the various taxa are simply not available, it may be necessary to limit species identifications to generic or even family determinations, and to use number or letter designations for the species involved. Special effort will be made to get determinations for the more abundant and/or important species discovered.

(2) Density and Distribution

Sampling procedures will be established to determine the distribution and density of the species involved. This information will also be collected and tabulated on a time scale to give seasonal and yearly fluctuations. For each species, the degree of resolution in such assessments will depend upon the success of the sampling procedures, population density (i.e., sample size), and the importance of the species involved.

(3) Interrelations with Other Elements of the Ecosystem

During the course of the field work, observations will be made to determine what part each of the more abundant and/or important

species is playing in the overall ecosystem. This will include such items as food habits, habitat requirements, predation or parasitism by other organisms, etc. Information of this nature will be sought in the literature for the species concerned or for related taxa to serve as a guide for direct observations, or to substitute for them. It is further anticipated that the synthesis of data from all sources in the final phases of the studies will elucidate many interrelations not noted or understood in the earlier stages of the monitoring and data gathering program.

Methods

Initially, walk-throughs will be conducted to provide a general familiarity with the terrain and flora and to determine sampling sites, accessibilities, etc. Sampling stations will be established in each of the three major vegetation types (i.e., riparian, shad scale falts and slopes, and greasewood draws). Stations will be established close to anticipated mining activities, at a greater distance on sites A and B and at one or more off-site check areas.

The principle sampling procedures will involve:

(1) Berlese Funnels

Soil and litter samples will be collected and the macro-invertebrates extracted from them by means of Berlese funnels.

(2) Pit Traps

Baited and unbaited pit traps (placed within areas "fenced" to prevent ingress or egress of the animals being sampled) will be used for certain non-flying, surface-inhabiting arthropods.

(3) Sweep Nets

Each of the more abundant and/or significant plant species will be sampled for resident or visiting arthropods by sweeping them at regular intervals with an insect net.

(4) Light Traps

Adult insects will be sampled for relative abundance on a seasonal basis by means of UV light traps and UV lights reflected from sheets of white cloth.

(5) Malaise Traps

Adult insects will be sampled for relative abundance on a seasonal basis by means of Malaise traps placed over paths of expected movement by flying insects.

(6) Bait Traps

Various materials such as decaying meat and excrement will be used to attract appropriate insects. "Fly traps" will be used in conjunction with these baits to trap flying visitors.

(7) Opportunistic Collecting and Trapping

Various arthropods will be searched for and collected by using whatever methods have been found productive by specialists (e.g., flying insects attracted to flowers will be netted from them; nest-building insects will be discovered by searching for nests and setting out trap nests or nesting materials; ectoparasites will be taken from vertebrates captured; wood-boring insects will be reared from infested wood; the presence of soil inhabiting immatures will be determined by means of emergence traps placed over appropriate areas). Rearing of arthropods on host plants from the site and of parasites from captured hosts will be undertaken on a very limited scale because of limited time and personnel available.

Observations of invertebrate populations and activities and the conditions affecting them will be conducted on a bi-monthly schedule with extended sampling activities during critical periods (e.g., reproductive season).

Purpose of Methods

The various observations and sampling procedures outlined are expected to provide a picture of arthropod diversity as expressed in lists of taxa and of spatial and temporal distribution and density of the more abundant and/or important species as expressed in tables and compiled on computer sheets. The study will provide data for determination of temporal factors in the life histories of significant species as well as host plant pereferences of phytophags. Host information for forms with other food habits

will be qualitatively described from general observations, baiting, searches on captured vertebrates, etc. Rearing procedures should provide valuable biological observation although they will probably be used only for the most critical species.

Impact of Collecting and Sampling Procedures on the Site

Most invertebrates occur in such large numbers that the removal of individuals in the sampling and trapping procedures will have no measurable effect on the populations.

None of the anticipated procedures should have any significant effect on the environment.

Work Schedule

Results will be reported in the semi-annual reports (April and October). The work progress is expected to be approximately as follows:

1974

Walk-throughs will take place in July, sampling stations will be chosen, and sweep samples will be started. Other sampling methods will be instituted as permission is received. By the end of the year the collection will be well underway and routine sorting and counting begun.

1975

During the year, auxiliary sampling and collecting methods will be established. By the end of the year the species list should be virtually complete with all genera named and species identified, at least by arbitrary numbers. Routine sorting and counting of the 1974 and 1975 samples should be nearly complete, but may not be finished until the beginning of the field season in 1976.

1976

Emphasis will be on observations of interactions between elements of the biota and on environmental responses. Limited rearings will be done to more precisely define food habits of important species. Synthesis with other elements of the ecosystem will be undertaken during the year and should be completed during July.

3. AQUATIC ECOLOGY

The aquatic ecosystem on tracts Ua and Ub consists primarily of the White River. Evacuation Creek runs part of the year and many ephemeral streams run briefly during the spring run-off and after thunder storms. There are no ponds or lakes on the study site although some pools persist on Evacuation Creek after the stream dries up in the summer.

The type of organisms which are found in an aquatic system are determined by the physical and chemical characteristics of the water and substrate (stream bed). Some of the more important ecological factors are:

1. The amount and type of dissolved salts in the water
2. The amount of suspended solids in the water
3. Current speed
4. Water temperature
5. Dissolved oxygen content
6. The nature of the bottom material

These factors are all important in predicting the flora and fauna which will inhabit a stream. Very important factors in the ecology of the White River are the amount of suspended solids and the type of bottom material. The color of the White River gives a clue to the amount of suspended material which it carries; it could well be called the "Brown" River. The characteristic color of the river is caused by suspended silt particles which are washed in from the easily erodable soils of

the watershed. These suspended particles prevent light from reaching the stream bed. Plants require light for growth; since light does not penetrate, there is very little growth of periphython or aquatic plants. Periphython is a community of microscopic plants and animals which become established on submerged materials (stones, sticks, etc.). The community is important in producing oxygen which dissolves in the water, but perhaps more important in providing food for small insects and crustacean herbivores which in turn are food for larger animals. In the White River and Evacuation Creek the silt affects organisms in two ways; it blocks out light and forms muddy bottom deposits which smother bottom organisms and some fish. As a result of these conditions, the streams support relatively little biological activity.

Station selection criteria for this portion of the study is much the same as used for siting hydrologic stations. Considerations include compliance with regulations (Federal Register, Nov. 30, 1973) accessibility, location of disposal sites, tributary confluences and drainage patterns. Aquatic organisms are affected by the chemical and physical environment; their activities and biochemical reactions in turn affect the characteristics of the water. Because of this interaction, biological stations will be located near the hydrologic stations.

The aquatic study will concentrate on the White River. Stations will be tentatively located as follows:

1. Upstream of tract U-b on the west side of Section 34, Township 9S, Range 25E
2. Below the confluence of Evacuation Creek in the Northwest 1/4, Section 7, Township 10s, Range 25E
3. On the Northwest corner of the NW 1/4, Section 14, Township 10S, Range 24E
4. On the northeast corner of the northeast 1/4, Section 21, Township 10S, Range 24E
5. Near the northwest corner of the southwest 1/4, Section 23, Township 10S, Range 23E

The stations will be located to include different flow characteristics, i.e. pools, riffles, eddies, etc. This should result in slightly different flora and fauna lists for each station.

Intermittent streams will be monitored seasonally during run-off periods. Stations will be established at any persistent pools which may be discovered during the preliminary study.

a. Parameters Measured

The aquatic ecosystem will be sampled to determine species composition, diversity, distribution in space and time, overall abundance and productivity of the biological community. The study will concentrate on aquatic macrophytes (vascular plants and filamentous algae) periphyton or "aufwuchs" (attached microscopic plants and animals) macroinvertibrates and fish.

b. Methodology

Methods to be used in this study will generally consist of accepted methods as described in "Standard Methods for the Examination of Water and Wastewater," 13th Edition, USPHS, 1971; "Timnological Methods," Paul S. Welch, 1948; "Methods of Hydrobiology," Jurgen Schwoerbel, 1970 and other recognized manuals of methodology. During periods when the stream is navigable a flat bottomed boat will be used for collecting. Depending on stream conditions, the boat will be launched at the Highway 45 bridge, and collections made on the way upstream. During low water periods, the boat will be launched at Station No. 1 and floated downstream. The second day of sampling will be conducted in a similar manner from the bridge to Station No. 5, downstream of Tract U-a. A third and possibly fourth day will be required for recapture seining to establish fish populations. Winter sampling will be conducted by using a four wheel drive vehicle. Possible ice cover will present an obstacle to sampling fish populations. Gill nets can be effectively used under ice; however, they are fatal to captured fish. Methodology for collection under these conditions will be established to the satisfaction of biologists of the Bureau of Land Management and the Utah Division of Wildlife Resources.

During the course of the study, methodology will be adjusted as necessary and as permitted by the Mining Supervisor.

Aquatic Macrophytes

Macrophytes are larger plants of all types. They are sometimes attached to the bottom (benthic), sometimes free floating and sometimes emergent (*Standard Methods for the Examination of Water and Waste Water*, 13th Edition, USPHS, 1971). As defined here, aquatic macrophytes will include filamentous algae (*Cladophora Spirogyra*, *Stigeoclonium*, etc.).

Recent observation and earlier studies indicate a generally depauperate aquatic flora. Sampling stations will be located to take advantage of the most abundant growth which may appear. These areas will be selected for their ability to demonstrate environmental change, rather than as areas representative of the system. Macrophytes will be collected qualitatively to determine species composition and relative abundance of emergent and submerged plants. Square meter plots will be established for quantitative measurement of productivity. Growth will be established for quantitative measurement of productivity. Growth will be cropped, dried and weighed. Productivity will be expressed as grams per square meter.

Periphyton or "Aufwuchs"

Periphyton is a community of microorganisms which are associated with the surface of submerged objects. The community usually includes smaller algae (*Oedogonium*, *Gornphonema*, *Rivularia*, etc.) protozoans and minute animals. Rock scrapings, submerged plants

and artificial substrate will be used to collect this community. The organisms will be identified by the use of dissecting and compound microscopes, photo micrography, and identification keys. The organisms will be keyed to genera and when practical, to the species level. Many of these microorganisms can be identified to species only by elaborate study.

Artificial substrate will be placed in the stream on each collection trip and recovered at the next bimonthly sampling period. hlorophyll will be extracted and measured by spectrophotometry in accordance with Standard Methods (USPHS). Results will be recorded as mg chlorophyll a/m^2. This procedure will be accomplished by the Utah State University Foundation.

Plankton

Plankton comprises a community of small, usually microscopic plants and animals which are suspended in the water. They are usually nonmotile or are insufficiently motile to overcome the effect of currents, hence they drift as the current carries them. Plankton is broadly divided into two groups, plant and animal. The plant group, known as phytoplankton consists mostly of unicellular to extremely small bits of unicellular algae; the zooplankton is a community of animals ranging up to several millimeters in length. The community is generally abundant and diverse. In a turbid, turbulent river little may be encountered. Much work has been accomplished on plankton and many of the

plants and animals can be characterized in terms of the type environment in which they flourish. Larvae of the genus Chironomus for instance are able to grow in waters with low concentration of dissolved oxygen. Since many other animals require oxygen, they cannot compete with Chironomus for food and space, and the latter flourish. As a result of this trait, characteristics of a stream can often be deduced from the types of populations which are present and those which are not.

Plankton will be sampled qualitatively with a hand plankton net constructed of #16 silk bolting cloth which has an aperture size of 0.086 mm. The net will be swept ten times at each location. The catch will be preserved in 50 millileters of 70 percent alcohol, 25 percent water and five percent glycerin. The plankton from the sample will be examined, identified and assigned a relative abundance value. Quantitative plankton samples will be taken in triplicate with a Kemmerer or gemware type collecting bottle at a depth approximately midway between surface and bottom. One of the samples will be fixed by the addition of formalin which halts biologic activity. The sample will be stored in the dark as soon as possible, frozen, and sent to the Utah State University Foundation for chlorophyll a analysis. Chlorophyll will be extracted per Standard Methods (USPHS, 1971) and used to establish productivity on a mg. chlorophyll per liter basis.

Replicate samples from the quantitative sampler will be strained

to concentrate the material. These samples will be stored in a standard volume (25 to 50 ml) of preservative. One sample will be analyzed, the other maintained as a reserve in case of mishap to the analytical sample. The reserve sample will be available for scrutiny by interested individuals or organizations. Each sample will be coded to show date and location of collection.

Species composition and population densities will be established by microscopic examination. Identification will be facilitated by use of keys pertaining to the Utah area. Abundance will be established in accordance with Standard Methods for the Examination of Water and Wastewater (USPHS, 1971), Section 601D.

Macroinvertebrates

Macroinvertebrates are defined as the larger invertebrates which are retained by a U.S. Standard No. 30 sieve. The community consists of worms, insects, crustaceans and other arthropods, many of which are bottom dwellers (benthos). The community is important as a food supply for the fishery resources of a stream. The macroinvertebrates will be sampled qualitatively with water nets, screens, and other routine methods. Existing techniques for quantitative sampling are inadequate or impractical for purposes of statistical analysis (Usinger, R.L., 1971; Aquatic Insects of California).

In spite of their shortcomings, the methods below are the best available. They are quite effective in determining qualitative

characteristics of the populations and fairly adequate for quantitative determinations. The Petersen or Ekman dredge will be used for bottom sampling in pools and deep areas. The jaws of these samples are spring loaded. The operator locks the device in the open position, lowers it to the bottom, and closes it by dropping a weighted messenger. The device snaps closed and picks up a specified portion of bottom material (about one square foot). The Ekman dredge is usually used on soft bottoms, the Petersen on hard.

Shallow areas and riffles will be sampled with Surber or Hess type bottom samplers. These devices are placed on the bottom; the bottom materials upstream are agitated to dislodge attached organisms. The organisms are washed into, and captured by the sampler. Cone emergence traps will be used if emergent insect larvae are found. These traps are anchored in the water and capture midges and organisms which emerge from the bottom in a given area.

Macroinvertebrate collections will be coded with date, location and method of collection. Most of the aquatic samples will be stored in 70 percent ethyl alcohol. Organisms will be identified by examination and the use of literature pertaining to the Utah area. Sample specimens will be submitted to Utah State University for confirmation of identification. Population characteristics will be calculated and recorded.

Fish

Past collection efforts on this section of the White River suggest that few fish will be encountered. (Olsen, Peter F., 1973; Wildlife Resources of the Utah Oil Shale Area).

During October and November of 1973, efforts were made to collect fish on four occasions. Methods used included electro-fishing, rotenone and explosives. These vigorous efforts produced only four fish; three flannel-mouth suckers and a speckled dace.

Several species of rare or endangered fish could occur in the White River; therefore, methodology of this study is designed to inflict minimum damage to the fish population. Primary sampling tools will be the seine and minnow traps. Supplementary methods including electro-fishing will be utilized as necessary and under the supervision of the Utah Division of Wildlife Resources. This agency will be involved in the study to the fullest extent possible.

Seining will be conducted at standard stations in various habitats, i.e., pools, riffles and eddies. Captured fish will be identified, weighed, measured, tagged and released. Seining operations usually collect amphibians, crayfish and insects. These organisms will be identified and recorded. Scales will be removed from occasional fish for aging purposes. Fish population numbers will be established by the mark-recapture method. Condition factors will be computed by the formula currently in use by the

Utah Division of Wildlife Resources. Representative samples of each species will be submitted to Utah State University for confirmation of age and identification. Suggestions, comments and critique will be solicited from the American Fisheries Society and concerned individuals and organizations.

c. Program Applicability

Aquatic organisms are useful indicators of the environmental conditions under which they live. Subtle changes in the physical and chemical characteristics of a stream may lead to changes in the species composition and overall abundance of aquatic organisms. A chemical monitoring system which samples a stream periodically may not detect a pollutant which passes the station between sampling periods; however, the presence of pollutants can be detected by changes in the biological community. In interpreting these changes it is important to understand natural changes which occur in a stream. Many species appear only seasonally; for example, most stonefly and caddis larvae are absent during the summer (Gaufin and Tarzwell, 1952; "Aquatic Invertebrates as Indicators of Stream Pollution". Pub. Health Rep., Wash. 67,1:57-64). Species composition and productivity will vary seasonally and between stations; however, conditions are roughly parallel from year to year at any given site.

Data on aquatic ecology will be accumulated over a period ex-

tending approximately from August, 1974 to September, 1976. Comparison of these data will reveal any changes which occur during the period. Chemical and physical data compiled during hydrologic investigations will be correlated to biological data to permit analyses of any changes which occur.

d. Schedule

July, 1974: Preliminary study will commence. Precise station locations will be established within the boundaries discussed previously. Qualitative samples will be taken and analyzed to establish community types.

August, 1974: The system will be sampled in the field. Samples will be analyzed in the laboratory for the preparation of the Ecological Interrelationships Baseline Study Report.

October, 1974: The first year monitoring program begins. Field sampling and lab analyses will be conducted on a bi-monthly basis. Additional study will be conducted as necessary during peak periods of biological activity. Semi-annual reports will be prepared beginning in April, 1975.

e. Potential Damage from Scientific Activities

In a remote environment like that of the Utah shale area, any activity of man is apt to result in ecological damage. This possibility was considered during the study design. Some of these considerations follow:

1. Equipment dealers suggest that an "air boat" would provide ideal transportation. The suggestion was rejected because the excessive noise produced by these machines will disturb animals.

2. A boat will be used to the fullest extent practicable to reduce the use of off-road vehicles. An ancillary benefit will accrue through reduction of dust generation.

3. Gill nets are an effective device for capturing fish; however, they kill captured fish which could include rare or endangered species. Use of this tool will be minimized, i.e., under ice only.

4. Sampling trips will be coordinated with biologists from the Bureau of Land Management and Utah Division of Wildlife Resources to minimize interference with animal activity.

5. Suggestions and comments on the study will be solicited from concerned individuals, organizations, and recognized experts in the field of aquatic ecology.

4. ECOSYSTEM ANALYSIS

The baseline data from the various vegetation and wildlife studies will be used to compile a synthesis of the characteristics of the existing ecosystem. The information developed on plant species density, dominance and frequency will be standardized into relative amounts and incorporated into an Importance Value (IV). An IV represents the relative status of a given plant species to all other species in a given sample. When all species have been assigned an IV, the samples can be visually displayed using Coordinate Axes (ordination) and graphs (dendrographs) to show relationships between the various samples. Tendencies between environmental gradients (moisture, soil texture, substrate, etc,) and vegetation composition are easily discernable from these graphic displays. Concurrently, the successional characteristics to the landscape will be assessed. Successional processes are of considerable importance in any understanding of the variation in population dynamics and ecosystem function. Since the oil shale leases cover landscapes where rainfall is known to be marginal, succession after a disturbance will be a major concern to any revegetation plan that may be devised. Species tolerances to high salts in the soil will also be important and naturally effect succession.

Finally, the data from the various wildlife studies will be analyzed to produce an understanding of the food web and trophic relationships for the Utah ecosystems. In combination with the plant community analysis, the general ecology of the region will then be established.

D. GEOLOGY AND SOILS

(Forthcoming)

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D. GEOLOGY AND SOILS

1. GEOLOGIC INVESTIGATIONS

a. General

A geologic investigation of Tracts U-a and U-b and vicinity will be conducted to document geologic conditions and establish a baseline for monitoring possible effects on the geologic environment as a result of the proposed mining activities. The investigation will include an in-depth study both in the office and field of the regional geology, site and vicinity physiography, stratigraphy, structure, and seismicity. Actually, the investigation will extend approximately one (1) mile beyond the boundaries of Tracts U-a and U-b and additional areas in Sections 5, 6, and 7 of T10S, R25E and Sections 25 and 36 of T10S, R24E. It is possible for the purposes of clarifying geologic conditions that limited areas beyond one (1) mile of the boundaries may be selected for reconnaissance. Such areas will be delineated as they become known.

The investigation will include a review of available geologic literature, aerial photographs, and maps; geologic mapping of the site and vicinity at an appropriate scale (preferably on the order of 1 inch = 1000 feet) on color stereographic aerial photographs, and measuring and describing the stratigraphic section from the Mahogany marker of the Parachute Creek Formation to the Uinta Formation ("B" unit); and interpretation of

subsurface data from borehole lithologic logs, geophysical logs, core samples, shallow trenches (up to 16 feet deep), and shallow seismic refraction profiles. The borehole drilling and logging will be done for the groundwater investigation and are discussed in detail in that section.

b. Physiography

Analysis of site physiography with regard to its relationship to geologic features, drainage patterns, slope gradients, and topographic relief will be performed. This analysis will be useful in planning optimum road systems, selecting suitable spent shale disposal sites, evaluating flash flooding potential in areas considered for monitoring operations, developing design parameters for proposed mining facilities, and determining extent and method of containment necessary to avoid surface water contamination by materials or fluids discharged during drilling, mining, and/or refining activities.

The physiographic study will utilize stereographic black and white, color, and color infra-red aerial photographs, topographic maps (USGS 7½ minute quadrangles and others), and data collected during literature review and field reconnaissance. Physiographic data will be discussed in a report and will include maps indicating such things as spent shale disposal sites and dam or containment pit locations.

c. Stratigraphy

The stratigraphic relationships of pertinent geologic units which underlie the area of investigation will be described in detail. Data for these descriptions will be derived from available literature, surface mapping of exposures, and observing borehole cuttings, core samples, and geophysical logs from test boreholes. Based upon present information, such descriptions and measurements will primarily include portions of the Parachute Creek member of the Green River Formation, the lower Uinta Formation ("A" unit), and Quaternary materials. However, further investigation may indicate the necessity to include additional members or formations.

The primary purpose of surface mapping is to define the areal distribution, true thickness, and continuity, of the pertinent geologic units as well as their physical description. Descriptions of stratigraphy within the area of investigation (Tract boundaries plus one (1) mile) will include noting the locations of minerals, fluids, or gasses of economic and environmental importance, such as gilsonite, bituminous sand, sodic minerals (nahcolite, dawsonite, and so forth), hydrocarbons, water, and paleontologically significant zones. Mapping will be completed utilizing four-wheel and two-wheel drive vehicles, motorcycles, and/or walking. Existing roads or trails will be used for the most part. Cross-country travel for mapping purposes will utilize the latter two methods, thus minimizing ground disturbances.

Describing and measuring Quaternary materials, which occur in limited areas, will be done by observing surface outcrops and using one or a combination of the following: shallow seismic refraction profiling, trenching with a backhoe to depths of 16 feet or less, and examination of cuttings or samples from boring through the materials with a flight auger, bucket auger, or rotary drill rig.

Trenches to depths up to 16 feet will be excavated with either a rubber tired or track mounted backhoe using a 24 inch wide bucket and equipped with proper safety equipment including spark arresting attachments. Trenches deeper than five feet will be shored in accordance with OSHA specifications for the materials encountered prior to personnel entering for geologic inspection. Personnel working around and in trenches will observe all OSHA safety regulations with regard to equipment and practices. Trenches will be backfilled upon completion of geologic inspection and removal of shoring. Backfilled materials will be given a nominal degree of compaction to minimize subsidence, and the area will be graded to as near original condition as possible and revegetated.

Borings to determine alluvium thicknesses may be drilled with flight or bucket auger drill rigs. Depths to bedrock will be determined from one or a combination of relative drilling ease, spoils/cuttings inspection, or direct observation downhole. Cross-country travel with these rigs will be necessary for such

exploration; however, grading or scarifying of travel routes will not be necessary as these rigs can transverse the relatively level valley areas and low vegetation successfully. Areas of drilling and cross-country travel will be reclaimed by backfilling boreholes using nominal compaction of spoils, regrading drilling areas and travel routes as necessary to as near previous conditions as possible, and revegetating drilling areas and traverse routes as necessary.

Where practical, in order to minimize ground disturbance, rather than trenching or drilling, shallow seismic refraction profiling will be performed utilizing a Bison 1570B or similar instrument with the energy source being an eight (8) pound sledgehammer and strike plate. This method entails burying one or two geophones (three inches in diameter) in the alluvium to a depth of six to twelve inches and traversing, in selected increments, while hammering the strike plate located on the ground surface. Locations of the geophones and strike plate can be selected to avoid vegetation or other easily damaged entities, thus leaving very little sign of surface disturbance.

The geologically older rocks will be described and measured primarily by observing outcrops, which are numerous and extensive vertically. Traversing these vertical exposures will provide excellent measurements of thickness and descriptions of weathered surfaces. Borings on the tracts penetrating the stratigraphic section for groundwater information and monitoring

will be logged by a geologist, and in some cases core samples will be taken continuously or at designated intervals and borings will be geophysically logged. Surface exposures will be correlated to borehole lithologic logs, core samples, and associated geophysical log signatures to develop stratigraphic correlations across the sites. Stratigraphic correlations laterally across the site or sites will be useful in determining extent of aquifers, if permeable zones exist, and the existence of stratigraphic units of economic importance.

Degree of environmental disturbance and reclamation, as well as proposed drilling procedures from which stratigraphic information will be derived, are discussed in the groundwater portion of this report.

d. Structure

The geometry of structural features such as joints, fractures, and faults will be studied and mapped. A thorough knowledge of these features is useful in determining slope stability characteristics; occurrence, vertical and lateral movement of groundwater and hydrocarbons in fractured zones, and may be of use in mine stability studies.

Mapping and analysis of the structural geometry will be done by stereoscopically viewing black and white, color, and color infrared aerial photographs, observing core samples from boreholes, and reviewing existing literature and maps. Plan orientation

(strike), inclination from the horizontal (dip), and spacing of joints, fractures, and faults observed will be mapped at an appropriate scale to provide an overall view for interpretation of the structural relationships on the tracts and their vicinity.

Surface and subsurface information for structural analysis will be collected concurrently with stratigraphic and groundwater data. Therefore, drilling, trenching, and mapping procedures, as well as amounts of surface disturbance and reclamation are discussed in the related sections.

2. GROUNDWATER

a. Purpose and Scope of Investigations

The objective of this study is to investigate the groundwater system underlying prototype oil shale Tracts U-a and U-b to determine the effects groundwater will have on all mining operations and to evaluate the impact these activities will have on the regional hydrologic system. Such a program will require a thorough search of the existing water resources literature and studies currently in progress in the Uinta Basin. University faculty, federal, state and local authorities, well drillers, as well as mining and oil company engineers will be interviewed to acquire any information concerning the groundwater systems. An inventory of all wells within twenty miles of the site will be performed to locate all aquifers, measure depths to water, and tabulate water use, well yield, and other aquifer characteristics. Whenever available, well logs, pump test data, water quality analyses, and geophysical logs will be obtained from those wells within twenty miles of the site.

Water level and water quality contour maps will be prepared from the inventoried wells to determine regional baseline groundwater flow directions and rates, as well as the regional baseline distribution of chemical species.

On each tract, baseline groundwater data will be collected on the sites by drilling and geophysically logging pilot holes to locate

all water-bearing zones above and within 400 feet below the Mahogany oil shale zone. Pump tests will then be conducted in each water-bearing zone defined in the pilot holes to determine the aquifer characteristics. Observation wells will be drilled into each water-bearing horizon and in numerous locations around and within the disposal sites to monitor water level and water quality. This information will then be integrated into the regional groundwater investigation to determine the direction and rate of groundwater flow beneath the sites and to assess the potential for contamination of surface and groundwater resources due to mining operations. This study will also be used to determine the effects mine dewatering and oil shale excavation will have on the regional groundwater system. If sufficient data become available, groundwater conditions may justify the application of groundwater models to analyze various interrelated components of the groundwater system.

After these baseline data are collected and mining operations begin, the system will be monitored for changes in water level and water quality to insure mine safety and to preserve the integrity of the hydrologic system.

b. Occurrence of Groundwater

Due to time constraints, a brief and somewhat incomplete preliminary investigation was conducted on the regional occurrence of groundwater in the Uinta Basin to direct the

proposed on-site testing and monitoring program for groundwater. The following few paragraphs summarize the investigation.

Unconfined groundwater occurs perched in the alluvial and terrace deposits near the White River flood plain. No springs or seeps are reported in the bluffs along the river indicating that sediments above the flood plain are dry. The American Gilsonite Company operates several water wells drilled about 50 feet into the alluvium producing an estimated 10 to 40 gallons per minute. A deep exploratory well, in Section 17, T10S R24E, produced water at an estimated rate of 300 gallons per minute from a depth of 30 feet in the White River alluvium.

Beneath the alluvial and terrace deposits are the Uinta and Green River Formations dipping gently to the northwest. Permeabilities in these competent units are of both the porous and fracture type. Apparently the fracturing is not as abundant here as it is closer to the north limb of the synclinal basin where oil is produced from relatively well fractured zones in the lower Green River and underlying Wasatch Formations.

The Uinta Formation consists primarily of fine-grained sandstone and siltstone with some pebble conglomerate and marlstone. The American Gilsonite Company advanced several shafts to approximately 1000 feet through the Uinta Formation. No groundwater was observed in porous strata, but at their Bonanza Mine, north of the tracts, 50 gallons per minute are pumped

year round from the mine where sulfide-rich surface water seeps downward along irregularly spaced fractures. A hydrologic test hole 18 to 20 miles west of the oil shale tracts in Section 36, T9N, R20E was drilled through the Uinta Formation and studied by the USGS, however, no water-bearing zones were encountered. No groundwater was encountered in the Uinta Formation in four oil shale exploratory holes on Tract U-a.

The Green River Formation consists of an upper member, the Parachute Creek, and a lower member, the Douglas Creek. The Parachute Creek member is primarily marlstone, siltstone, tuff and the Mahogany oil shale zone. The Mahogany zone is located near the center of the 1000 foot thick Parachute Creek member. The Douglas Creek member contains algal and oolitic limestone with sandstone, siltstone and some shale.

In Section 13, T11S, R23E, a gas well produced water from below the Mahogany zone at a depth of 675 feet and flowed to the surface at 70 gallons per minute. Artesian water was also encountered in shaley sandstone just below the Mahogany oil shale bed in Section 7, T11S, R24E, flowing at 175 gallons per minute. The well tested by the USGS encountered three water bearing zones below the Mahogany zone which combined to produce five gallons per minute of flow at the surface. The tranmissivities of these zones ranged from six to eighteen gallons per day per foot. An exploratory hole in Tract U-a encountered

water flowing 45 gallons per minute at 360 feet above the Mahogany zone.

Recharge to the Uinta and Green River Formations occurs along the upturned edges of the synclinal basin principally by percolation of snow melt through the outcrops and along fault zones.

Groundwater is expected to flow down-dip in a northwesterly direction toward the center of Uinta Basin and vary in quality from fresh to saline. Water also occurs in several oil producing zones below the Parachute Creek member and probably older formations several thousand feet below the oil shale tracts.

c. Aquifer Testing

To determine the occurrence of groundwater and evaluate the aquifer characteristics underlying the oil shale tracts, three pilot holes will be continuously cored to approximately 400 feet below the base of the Mahogany zone. Pumping tests will be conducted at the following three locations using the pilot holes as observation wells: Section 13, T10S, R24E, 500 feet from the east section line and 600 feet from the north line; in Section 21, T10S, R24E, 1000 feet from the west line and 2,200 feet from the north line; and in Section 34, T10S, R24E, on the east section line and 2,640 feet from the north line.

Air rotary drill rigs will cut a 3" diameter core to investigate

fracture zones and lithology and to determine the depth and rate of fluid flow when water is encountered during drilling. Before and after each work shift, depths to water will be measured in all borings using an electric probe and/or a steel tape.

A 5 (±) inch diameter observation hole will be drilled to 400 feet below the base of the Mahogany zone at each site by the air rotary method approximately 50 feet northwest of each of the three pilot holes as shown in Figure 1. Samples of drill cuttings will be obtained at ten foot intervals and depth to water bearing zones and flow rates recorded. Immediately after completion, both the core and rotary holes will be geophysically logged to locate water-bearing zones and determine borehole flow velocity, extent of fracturing, porosity and lithology using the following techniques: spontaneous potential, single point resistivity, natural gamma, gamma-gamma, neutron-epithermal neutron, neutron gamma, fluid temperature, borehole flow meter, tracejector, fluid resistivity, three-dimensional sonic, and caliper. While these data are being analyzed, pump-in type packer tests will be conducted to determine in-situ horizontal permeability according to procedures outlined in Designation E-18, USBR "Earth Manual," 1968 edition. Pneumatically inflated straddle packers will be spaced 25 feet apart to test the entire length of the core borehole or selected specific zones.

Approximately 25 feet southeast of the pilot hole at each pump test location, a pumping well will be air rotary drilled into

each water bearing zone. A 12 (±) inch diameter hole will be fitted with 10-3/4 (±) inch diameter surface casing to prevent sloughing. Beneath the surface casing a 10 (±) inch diameter hole will be drilled to the top of the deepest water bearing horizon. An 8-5/8 inch diameter (24 pounds per foot) casing will be installed and the annulus (between the casing and the borehole) grouted with concrete from the bottom of the casing to the surface. After the grout hardens, a minimum 7-7/8 inch diameter bit will be used to bore to the base of the water producing zone. If this hole remains open, the well will be developed by surging, jetting and bailing the drilling fluid from the well. In the event rock material sloughs into the hole, 6-5/8 inch diameter (18 pounds per foot) steel casing will be installed with slot perforations opposite the production zone. The well will be developed as previously discussed.

The submersible pump used for the aquifer test will be selected on the basis of flows observed in the pilot holes. Since the yield of water bearing zones appear to be variable, more than one pump may be required for aquifer testing, i.e., tests in low yield aquifers require pumps of smaller capacity. The submersible pump will be installed with a 1/4 inch diameter rubber high pressure airline and air pressure gauge to monitor water levels in the pumped well during the test. The test pump will be operated for about six hours to determine the sustained capacity of the well prior to actual testing.

Into each of the two observation wells, located approximately 25 and 50 feet north of the pumping well, a 2-1/2 inch diameter pipe will be fitted with a single hydraulically inflatable packer just above the lower end of the pipe. The assemblies will be lowered to the top of the lowest water-bearing zone to be tested and the packers inflated.

An airline will be lowered inside the 2-1/2 inch pipe to the base of the packer and connected at the surface to an air pressure gauge to monitor water levels during pump testing.

The submersible pump will be first operated in the well penetrating the lower water-bearing horizon for approximately 24 hours at the sustained capacity. Pumping will be maintained at a constant rate and discharge monitored using a Parshall flume. Water level changes in all the pumping wells and in the two observations wells will be systematically observed and recorded. The water pressure readings will be calibrated and re-checked periodically using a steel tape to measure water levels. The data will be plotted on graph paper in the field to detemrine the reliability of the tests. Water quality samples will be obtained at least hourly during the pump test and analyzed in the field for specific conductance. If specific conductance remains constant, there is probably no leakage between aquifers and only one water quality sample will be required for a complete laboratory analysis.
After pumping tests, water level recoveries will be observed and

recorded for 24 hours after pumping stops.

The submersible pump will then be removed and a suitable pump installed in the well completed to the bottom of the next higher water bearing zone. The packers will be deflated, removed from the observation holes and grout placed to the top of the water bearing zone just tested. After the grout hardens (approximately 24 hours), the packer and airline assemblies will be placed back in the observation holes just above the next highest zone designated for aquifer testing. The submersible pump will again operate for a six hour period to determine the sustained capacity and the same pump test procedure followed until all zones are tested. Field data will be analyzed using the "leaky aquifer" test method to determine transmissivity; storage; and, if a semi-permeable confining bed is present, the coefficient of vertical permeability.

Upon completion of testing, 2 inch diameter steel casing will be slot perforated and set in each observation well within the uppermost water bearing horizon on top of the grouted zone. The wells will be gravel packed to the top of the perforated interval and the annulus between the casing and borehole wall grouted from the top of gravel to the surface. A tight fitting, removable locking cap will be placed on each observation well and each pumping well, and equipped with a shut-in pressure gauge to read artesian water pressures. Pressure readings or depths to water measured with a steel tape will be obtained

monthly, and water quality samples extracted at least quarterly from each pumping well and from any accessible wells within 20 miles of the site. Water quality samples will be analyzed for the same constituents as surface waters discussed in Section

The pump test data will be analyzed to determine the coefficients of vertical and horizontal permeability, to estimate the volume of water which could seep into the mine, and then design a dewatering system if necessary. These data will also be used to compute the rate of seepage from the mine to underlying strata. Barriers to groundwater flow and points of groundwater recharge will be investigated using the pump test analyses.

The pump test data and water quality analyses will be used to evaluate the aquifers as potential sources of water suitable for use in mining operations and for consumption by project personnel. Water level and water quality data obtained during the monitoring program will be incorporated into regional contour maps prepared quarterly for each water-bearing zone. Water level contour maps will also be used to determine the direction and rate of groundwater movement in each water bearing zone. Water level change and water quality change maps will be derived from the contour maps to evaluate the impact of mining oeprations on the groundwater system.

d. Groundwater Monitoring at Retorted Oil Shale Disposal Sites

Based on preliminary studies, no water bearing zones are expected

to occur in permeable sediments in the first few hundred feet below the retorted shale disposal sites. However, the leachate from surface water runoff impounded by the proposed dams will probably inflitrate into permeable surface soils and bedrock. The purpose of this program is to investigate the potential for contamination of surface water and groundwater supplies from the vertical and horizontal seepage of leachate from the disposal sites.

To determine the expected rates of leachate percolation through surface materials at each disposal site, a soil survey and percolation tests will be conducted by Utah State University as described in Section

The subsurface flow of leachate from the disposal sites will be monitored by a network of approximately sixteen permanent observation wells. The locations and proposed depths of the wells are listed in Table 1 and illustrated in Figure 1. One well will be located near the center of the U-a disposal site, two wells drilled within the U-b site and the others will be located just outside the periphery of the disposal sites. In addition, well numbers M-17 and M-18 will monitor subsurface seepage between plant sites U-a and U-b and the White River. Following geologic studies, additional wells may be selected, or present locations modified slightly, to monitor possible leachate movement along joint systems transecting the disposal sites. If the three deep pilot holes indicate water bearing

TABLE 1

MONITORING WELLS AT DISPOSAL SITES

FOR TRACTS U-a AND U-b

Monitor Well Number	Depth of Boring (feet)	Location
M-1	200	NE¼ SE¼ NE¼ Sec 20 T10S R24E
M-2	100	SE¼ SW¼ NW¼ Sec 21 T10S R24E
M-3	200	SW¼ NW¼ NE¼ Sec 29 T10S R24E
M-4	100	SW¼ NE¼ SE¼ Sec 28 T10S R24E
M-5	600	C NE¼ SW¼ Sec 22 T10S R24E
M-6	1000	NE¼ SW¼ SE¼ Sec 11 T11S R24E
M-7	800	C SE¼ NE¼ Sec 34 T10S R24E
M-8	150	NE¼ SW¼ NE¼ Sec 13 T10S R24E
M-9	100	NW¼ NE¼ SE¼ Sec 13 T10S R24E
M-10	400	NE¼ NE¼ NE¼ Sec 23 T10S R24E
M-11	500	C SW¼ NW¼ Sec 23 T10S R24E
M-12	100	NE¼ SE¼ SW¼ Sec 36 T10S R24E
M-13	100	NE¼ NE¼ SE¼ Sec 13 T10S R24E
M-14	400	C NW¼ SW¼ Sec 29 T10S R24E
M-15	500	SE¼ SW¼ NW¼ Sec 6 T12S R25E
M-16	200	SE¼ SW¼ NE¼ Sec 20 T11S R24E
M-17	100	NE¼ NE¼ NE¼ Sec 15 T10S R24E
M-18	220	SE¼ SE¼ NW¼ Sec 12 T10S R24E

units above the Mahogany zone, additional observation wells will be installed to monitor the flow of leachate into the upper aquifers.

The observation wells will be drilled approximately five inches in diameter using the air rotary method to locate water bearing zones and to define other permeable and impermeable strata. If mud is used during drilling, the hole will be surged upon completion to clean the walls of the boring. Then, pump-in type packer tests will be conducted in each observation hole to determine in-situ horizontal permeabilities as prescribed in Designation E-18 USBR "Earth Manual." Pneumatically inflated double packers spaced 20 feet apart will be used to pressure test the entire length of the uncased hole. After testing, residual fluids will be removed from the hole using compressed air or bailer.

A 2 inch diameter steel casing will be slot perforated from the base of the hole to ten feet below land surface where a flange will be welded around the outside of the casing to fit tightly against the wall of the boring. The casing will be installed to protrude two to five feet above land surface, and will be cemented from above the flange to the land surface in order to prevent surface waters from entering the well. In wells M-4, M-12, and M-13 located within the disposal sites, additional lengths of casing will be installed as the elevation of the wastepile rises around the well. All wells will be equipped with

removable locking caps. Any monitoring well destroyed during active mining operations will be completely filled with cement and another well drilled at the nearest practical location.

Water levels will be measured monthly using an electric probe and water quality samples obtained at least quarterly in each observation well and in wells at other oil shale development properties adjacent to the two tracts. The water quality samples will be analyzed for the same constituents in surface water, as discussed in Section

Water levels and water quality data will be integrated if possible into regional water level and water quality contour maps. Water level change maps prepared quarterly will be used to observe the development of a groundwater mound beneath the disposal site. Water quality change maps will be used to estimate the rate of leachate seepage from the disposal sites and indicate where flow barriers, such as grout curtains, sheet pile or discharge wells, shoudl be constructed to prevent disposal site leachate from contaminating the hydrologic system.

e. Test Site Access

The locations of the pump test wells and disposal site monitoring wells were selected to minimize the construction of new roads. In most cases, drilling sites are within a few hundred feet of unimproved and light duty improved roads which will be utilized to the fullest extent possible. Where access is not available

by driving overland, a road approximately 20 feet wide will be graded to the site with a minimal disturbance to the landscape. Each drill rig will require a pad approximately 50 feet by 20 feet for working space around the boring. All access routes and pad locations will be coordinated through the Bureau of Land Management and all land disturbed in developing access routes will be reconditioned as prescribed by the Bureau of Land Management.

f. Containment of Test Fluids and Mud Pits

Air rotary rigs will be used whenever possible for drilling all pump test holes and monitor wells at the disposal site. Although borings drilled as monitor wells around the disposal site are not expected to encounter water, borings at the pump test locations will require a pit to contain formation water discharged during drilling. The pit will be centrally located to serve other wells at the site and will be initially constructed 30 feet long, 15 feet wide and 5 feet deep.

If significant quantities of water are encountered air rotary drilling becomes prohibitively difficult. In such a case, the rigs will convert to a rotary wash method using suitable drilling "mud." This will necessitate the construction of smaller mud pits approximately 15 feet long, five feet wide, and five feet deep adjacent to each rig.

The drilling mud will be circulated first to the large pit where

the drill cuttings will settle. The mud will then overflow through a narrow ditch approximately one foot deep by one foot wide into the small mud pit adjacent to the rig where it will be pumped back into the hole. Where firm bedrock occurs close to the surface, blasting may be required to enlarge the mud pits. If blasting is necessary, all permits will be obtained and all required persons and agencies will be notified.

Containment pits will also be required to hold water discharged during the pumping tests. However, the expected yield from the aquifer cannot be estimated until after the observation holes are drilled and geophysically logged. At that time, the large centrally located pit will be enlarged further, if necessary, to accommodate the volume of fluid discharged at the sustained capacity for the duration of the pumping test in each water bearing zone. For example, if three water bearing zones are each pumped at 50 gallons per minute for 24 hours, the containment pit would be approximately 50 feet long, 40 feet wide, and 15 feet deep. Materials from the pit excavation will be used as fill to dam natural drainages and prevent fluids from running overland.

Several borings and one pump test site are located in the valley bottoms of Southam Canyon and Evacuation Creek. In order to prevent flood waters from transporting the saline fluids contained in the pits into fresh water supplies, trucks will pump the fluid from the pits for disposal at designated waste

disposal sites as soon as tests are completed. If no suitable waste disposal site is located in the vicinity, the fluids will be spread in pits used at other boring or pump test locations.

As soon as each excavation is complete or when a partially dug pit is left unattended, a sturdy wire fence will be placed around each pit. The fence will be disassembled after testing when all fluids are removed either by evaporation or the vacuum trucks, the pit filled in, and the site reconditioned to the original state, as directed by the Bureau of Land Management.

3. SUBSIDENCE

Regional and local rates of historic and present subsidence/uplift should be documented prior to, or concurrent with, monitoring of potential subsidence. Subsidence in the tracts and adjacent areas, due to mining operations, may be considered possible from three main causes: groundwater withdrawal from deep aquifers due to commercial pumping and/or mine dewatering; excavation at depth in the form of room-and-pillar mining; and crustal loading from spent shale disposal.

Several methods, or variations of methods, are available to monitor subsidence and include precise measurement of both horizontal and vertical components of movements to increments on the order of 0.01 inch. In the site area and its vicinity existing stable USGS bench marks will be surveyed to the first order (these methods are described in Section). This procedure will involve at least 25 existing bench marks located within about ten miles of the U-a, U-b Tracts.

Additionally, approximately 25 stable monuments will be established in (3) and immediately around the proposed Evacuation Creek and Southam Canyon shale disposal sites (17), and in areas on and off site (5) where USGS bench mark coverage is sparce. These new monuments will be set in bedrock and the true horizontal and vertical positions will be determined by first-order surveying methods. The approximate tentative locations of these monuments

lie within about 15 miles of the tracts.

Semi-annual first-order surveys of these monuments will be undertaken beginning immediately after installation or establishment. A high degree of precision will be maintained by the surveyor with agreed upon acceptable tolerances. The data will be evaluated immediately and an interim report submitted.

Three or more precision tiltmeters may also be used to monitor subsidence by recording amounts of tilt of the land surface. These tilts are measured in seconds of arc or microradians from which amounts of subsidence can be computed. This instrumentation may be more costly and require a more sophisticated array of instrumentation than the monument system. Tiltmeters will provide a directional component toward the maximum subsidence (in ninety degree increments) which aids in pinpointing the source of maximum subsidence. Data is automatically recorded in ink on standard graph paper or on magnetic tape, and can be reduced by computer methods to yield quantitative evaluations. A monthly field check would be performed to retrieve data and service the instruments as necessary. Evaluations will be presented semi-annually in report and graphical form.

Installation of monuments and tiltmeters involves minimal land disturbance. Stable monuments can consist of a steel pipe properly imbedded in bedrock and cemented into place. Hand tools or light weight portable power augers can be used to create the

excavation for the monuments. Tiltmeters will also be placed on bedrock in shallow vaults or pits. These excavations may require a backhoe or auger drilling rig. The instrument is placed on a stable surface, properly calibrated and set to a known value. Sturdy fences will be placed around these instrument housings to avoid accidental disturbance or tampering.

4. SEISMICITY

Tracts U-a and U-b lie in an area of low to moderate seismicity between the Sevier Orogenic Belt to the west and the "mineral belt" in Colorado to the east (zones with histories of greater seismic activity). There is some potential for local small to moderate earthquakes (Richter magnitude < 5) in the site vicinity and with it a potential for ground shaking and some degree of related damage to underground mining operations and associated facilities. Seismic behavior of the site and the local region can be monitored with seismographs and strong motion accelerographs. The recording instruments now in operation in the region may be supplemented with near-tract, or on-site instruments. A strong motion accelerograph and a seismograph are being considered.

An array of continuously monitoring seismograph stations provides a method for obtaining detailed statistical information on seismicity as well as ground motion characteristics at the site. Although it is much more costly, the primary advantage of continuous monitoring over the "triggered" accelerograph is the completeness of the record, which would permit studying all small events that exceeded background vibration levels, rather than only those which exceed a pre-set trigger level. Removal of the records from the instrument would take place at regular intervals and processing would follow. The seismograph array

would allow accurate three-dimensional locations of micro-earthquake events occurring at or near the site, and would permit definition of acceleration, displacement and particle velocity levels at the site. A set of baseline micro-earthquake data would be available prior to mining operations to allow comparison to levels after mining begins in order to determine what effect if any operations have had on the local seismicity.

One, or possibly two (redundant systems should be considered to prevent loss of records due to instrument malfunction), strong-motion accelerographs may be emplaced as a surface installation within a centrally located area of the tracts. This instrumentation can be provided by few manufacturers and could consist of the Kinemetrics, Inc., SMA-1 unit, with an optional WWVB absolute time radio receiver (SMA-1-WWVB). The WWVB receiver provides the capability for real time correlation with other recording devices monitoring for other agencies. Recordings will be on 70 millimeter film or on a dry paper which can both be photographically enlarged to allow digitization.

Earthquake events producing at least .0025g (force of gravity) will trigger the strong motion instrument, this force being approximately equivalent to that developed by a Richter magnitude 3.0 at 15 kilometers distance. Accelerations up to 0.5g can be recorded on this instrument with the described trigger sensitivity. This option is chosen over the normal 1.0g because the expected earthquake shaking levels are low and the desire is for great

detail. Although epicenter location is not possible with one instrument or two closely spaced instruments, the acceleration and related data is easily derivable.

The strong-motion instrument will be checked bi-weekly to monthly, or more often if events are suspected, at which time film will be changed and a newly charged battery pack will be installed if necessary. Instrument calibration will be performed at about six-month intervals by a geophysical technician.

Data derived from either one or both kinds of instrumentation will serve to establish the current state of local seismicity. Levels of "shaking" due to recorded earthquakes will be evaluated with respect to proposed mine activities. Having established the magnitudes and locations of events (seismograph alternative) prior to mining, it can be determined if mining, changes in the groundwater regime, or crustal loading with spent shale has altered the seismic environment, and, if so, to what degree. Also, design data for room and pillar sizes, and for proposed structures can be better formulated.

Final instrument location will depend upon more detailed mine plan data, but an area near the midpoint of the boundary between Sections 22 and 23 of T10S, R24E appears suitable for the accelerograph. This area is near an occasionally used road and no significant access problems are anticipated. Second and alternate sites can be selected away from the more heavily

trafficed areas. Seismographs in the array would be located in approved off-site areas in conjunction with efforts by the USGS and Utah State University.

The SMA-1-WWVB and/or individual seismograph units will be installed on rigid concrete pads occupying less than 20 square feet Only minor leveling with hand tools will be required for emplacement and a sturdy fence of moderate height will be constructed to prevent tampering or accidental triggering. Concrete required for the pads will be mixed on-site by either hand or machine methods. All clean-up water and waste materials will be properly disposed of at accepted areas on or off site.

APPENDIX A

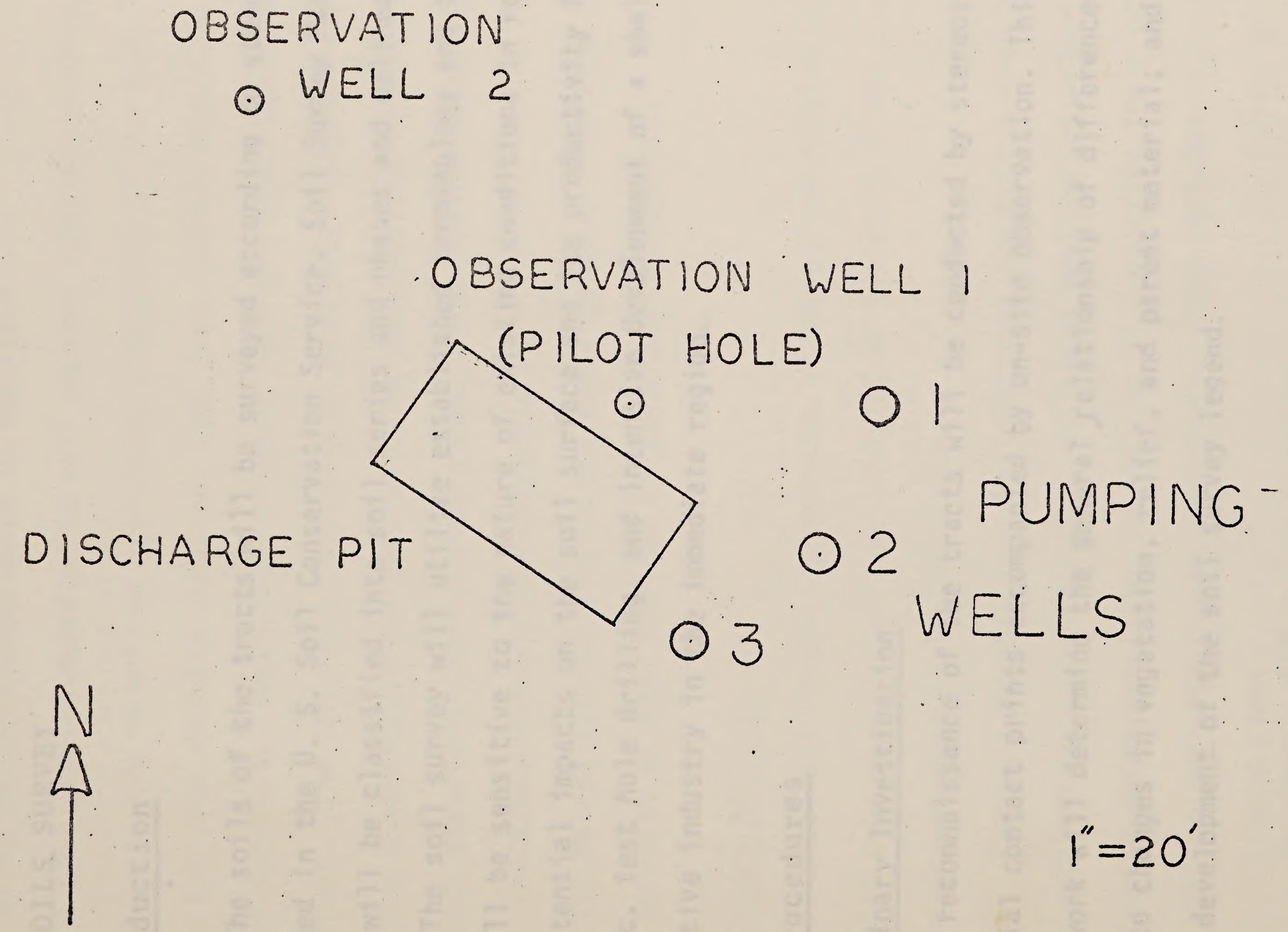

FIGURE 1

IDEALIZED PUMP TEST SCHEME FOR TESTING THREE AQUIFERS

2. SOILS SURVEY

Introduction

The soils of the tracts will be surveyed according to standard procedures oultined in the U. S. Soil Conservation Service, Soil Survey Manual. The soils will be classified into soil series and phases and delineated on a map. The soil survey will utilize established terminology and techniques but will be sensitive to the nature of existing conditions in relation to the potential impacts on the soil surface and its productivity from vehicle traffic, test hole drilling, and intensive development of a shale oil extractive industry in the immediate region.

a. Procedures

Preliminary Investigation

A reconnaissance of the tracts will be conducted by stereoscopic study of aerial contact prints accompanied by on-site observation. This reconnaissance work will determine the general relationship of differences in soil types to changes in vegetation, relief, and parent material; and be used in the development of the soil survey legend.

Field Investigation

The field survey will be conducted by walking over the land and digging holes with auger and spade to make soil profile descriptions of soil pedons. Similar pedons will then be grouped into mapping units and as mapping units are established paired samples will be collected from each mapping unit

for laboratory analysis. Aerial photographs (scale 1" = 1,000') will be used to delineate mapping units in the field.

A soil profile description will include information about the site where the hole is dug as well as describing properties of the soil. Information about the site includes location, land form, relief, elevation, drainage, parent materials, vegetation, climate, erosion, water table, stoniness, and rockiness. The individual horizons of each pedon will be identified using standard nomenclature and the following observations recorded: depth, color, texture, structure, consistance, roots, pores, coarse fragments, clay films, lime, reaction, boundary and temperature.

The paired samples will be collected by using a backhoe to expose the soil horizons so that they can be described and sampled.

Laboratory Analysis

Physical and chemical properties of the paired samples collected from the soil mapping units will be analyzed by the Soil, Plant, and Water Analysis Laboratory at Utah State University.

1. Physical Properties - Soil physical properties used in determining their engineering classification, estimated engineering properties and making engineering interpretations, as well as in predicting their production potential will be analyzed in the laboratory. They include:

Liquid Limit
Moisture - Saturation percentage
1/3 atmosphere
15 atmosphere
Particle-size distribution
Plastic Index

2. Chemical Properties - A careful assessment of critical soil chemical properties will be undertaken as a measure of their potential as a source of

nutritive elements as well as possible toxicity or limitations to production of vegetation. These chemical analysis will include:

- Boron
- Cation exchange capacity
- Extractable cations
    - Na
    - Ca
    - Mg
    - K
- Gypsum
- Iron
- Zinc
- Lime ($CaCO_3$ equiv.)
- Nitrogen (total)
- Organic Carbon
- pH
- Phosphorus (available)
- Phosphorus (Total)
- Potassium
- Salinity (Electrical conductivity)

Soil Correlation

As the soil mapping units are established they will be classified, named and correlated by procedures used by the Soil Survey Staff of the Soil Conservation Service. The soil mapping units would then bear the same Series name as a similar soil mapped in another area. Care will be taken to correlate the soil units with vegetation types and specific plant communities.

Preparation of the Report

1. Series Descriptions - Each soil series and representative profile will be described in the report. First the soil series is described and then each mapping unit in that series is described. Included in the soil descriptions are the general extent and location of the series, inclusions of other soils within the mapping unit, the dominant vegetation species, the present use of the soil, its capability and specific properties of importance to oil shale development.

2. Analytical Data - Laboratory analytical data will be tabulated for each soil series.

3. Estimated Soil Properties - Soil properties will be estimated using "Guide for Interpreting Engineering Uses of Soil" (Soil Conservation Service) and appropriate memos from the Utah Soil Conservation Service. These estimated properties will be tabulated and include the following: depth to seasonal watertable, hydrologic soil group, classification (USDA texture, Unified and AASHO), percent of material less than 3 inches, liquid limit, plasticity index, permeability, available water capacity, soil reaction, salinity, shrink-swell potential, corrosivity, erosion factor, wind erodibility group, flooding, high water table, cemented pan, bedrock, subsidence and potential frost action.

4. Interpretations for Selected Uses - Soil limitations or suitability ratings for selected uses will be rated as slight, moderate or severe (good, fair, poor for source materials) and major restrictive features listed, as outlined in "Guide for Interpreting Engineering Uses of Soil" (Soil Conservation Service) and memorandums of the Utah Soil Conservation Service Selected uses that will be rated include:

Source Materials - Road fill
Sand
Gravel
Topsoil

Sanitary Facilities - Septic tank absorption fields
Sewage lagoons
Sanitary landfill
Daily cover for landfill

Community Development - Shallow excavations
Dwellings without basements
Dwellings with basements
Small commercial buildings
Local roads and streets

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Gravel
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Sewage lagoons
Sanitary landfill
Daily cover for landfill

Community Development - Shallow excavations
Dwellings without basements
Dwellings with basements
Small commercial buildings
Local roads and streets

Water Management - Pond reservoir area
Pond embankment
Excavated ponds-aquifer fed
Drainage
Irrigation
Terraces and diversions
Grassed waterways

Recreation - Camp areas
Picnic areas
Play grounds
Paths and trails

Capability and Predicted Yields---Crops and Pasture - Irrigated
Non-irrigated

Woodland Suitability

Wind Breaks

Wild Life Habitat Suitability

Potential Native Plant Community (rangeland or forest understory vegetation)

The interpretations will be tabulated for each mapping unit. Special use colored maps may be developed from this information showing the suitability (i.e., severe-red, moderate-yellow, and slight-green) in separate colors.

Continuing Studies

Soil moisture and temperature will be monitored for a minimum of two years to obtain base-line data critical in assessing the site productivity and substantiating criteria for classifying soils at the family level. Sites will be selected most likely adjacent to where paired samples were collected for each mapping unit and neutron access tubes and thermocouples will be installed in quadruplicate at each site. The soil moisture content and soil temperature will be monitored at 15-day intervals.

b. Program Applicability

This study is an inventory of the soils in the two oil shale tracts. Included in the inventory are the types of soil, where the different soils

are located and the physical and chemical properties of the soils. This basic data is used to evaluate soil productivity, and identify areas having limitations for specified uses. This information is invaluable in selecting sites for development such as industrial sites, urban sites, recreation sites and location of roads and highways. Potential hazards such as erosion or reestablishment of vegetation on disturbed areas are identified so that procedures can be established prior to development to minimize undesirable impacts.

c. Work Schedule

Preliminary investigations	June 15, 1974 - Sept. 15, 1974
Field survey	Sept. 15, 1974 - Nov. 15, 1974
Laboratory analysis	Nov. 1, 1974 - Dec. 1, 1974
Writing of report	Dec. 1, 1974 - Mar. 1, 1975

d. Potential Study

The soil survey interpretive report supplies basic information for further investigations. Additional study would determine: procedures to control dust on soils which are highly susceptible to wind erosion, whether terracing or some other management practice might be used to impound runoff water and reduce water erosion, fertilizer requirements for reestablishment of vegetation, the need for leaching to reduce salinity, whether top soil should be stockpiled so that it can be top dressed back on toxic subsoil material. The feasibility of incorporating ground municipal garbage and sewage, Supersoil® with waste material to establish vegetation might be investigated.

E. HISTORIC, SCIENTIFIC AND AESTHETIC RESOURCES

1. ARCHAEOLOGIC SURVEY

The archaeologic investigation of the lease property will be performed in two phases: an initial assessment of the site area, which has already been performed, and a more thorough survey of the entire property, with concentration on the monitoring station sites and drill hole locations. This will be conducted prior to implementation of the monitoring program, including road construction and installation of equipment. This survey will take approximately two months and will begin in mid-July, 1974.

There are recorded archaeological sites on Tract U-b and the adjacent land along the White River. No new sites were discovered during the preliminary archaeological assessment of the lease area conducted under the direction of Professor J. P. Jennings, Professor of Archeology and Anthropology, University of Utah. This preliminary assessment consisted of an initial record check of all existing known sites on the tracts, followed by field spot-checking the areas of greatest potential. These areas were primarily just above the flood plain of the White River, Evacuation Creek, and Southam Canyon. This report, included in the Appendix highlights the areas of prime concern.

The Bureau of Land Management previously recorded one site

(42-UN-324) in the lease area. It is described as being a partially sheltered area along a small outcrop, with only minor evidence of occupation observed. There are also a few sites recorded in the general vicinity of the two lease tracts (see Appendix).

The next phase of investigation will include a detailed field survey of both tracts and areas outside the tracts that may be impacted. This survey will be conducted by the Utah State Archaeologist's staff. Areas that are planned for environmental monitoring facilities, above ground process facilities, roads, and disposal sites will be considered as critical areas and will be surveyed in detail as soon as possible.

The detailed surface survey will consist of thoroughly walking over all areas believed to be critical and recording and briefly describing any artifacts or signs of human habitation. The State archaeological crew will be assisted by the lease operator's antiquities staff, who will coordinate with the environmental scientists and mining engineers in planning around known sites or in arranging for the scientific excavation of sites should they be located in an area critical to the environmental program or proposed development operations. A detailed surface survey of all of the tracts and lands outside the tracts which may be impacted by the mining operation will be completed and a report of the results submitted to the Mining Supervisor prior to the construction or installation of any mining facilities.

Any scientific excavation of archaeological sites that might be required will be supervised by Dr. J. P. Jennings, Professor of Archaeology and Anthropology, University of Utah.

2. PALEONTOLOGIC SURVEY

Geologic formations in the region similar to those which occur on the project site have yielded several fossil locations. A detailed paleontological survey will be conducted by consultants under the supervision of D. Wade Miller, Associate Professor of Zoology and Geology, Brigham Young University. This survey will be conducted at the earliest possible date and will be followed by a report submitted to the Mining Supervisor, BLM, and other interested parties. Any sites that will require scientific excavation will be excavated by the lease operator's antiquities staff, in conjunction with a public institution, after approval of the Mining Supervisor.

3. HISTORIC SITES SURVEY

A field survey of the lease areas and areas outside of the tracts that will be impacted by the mining operations will be conducted by the State Archaeologist to locate and identify any historical sites affected by the project. There are several known historic features in the vicinity which will experience some degree of impact from oil shale activity even though not within or in direct proximity to the lease tracts. These include the Ignatio Stage Station; several abandoned gilsonite

mines along the route of the narrow guage Uinta Railroad; stage lines between Vernal, Watson and Nine-Mile Canyon; and the ghost towns of Dragon, Watson and Rainbow. A detailed regional and site history report will be written by the State historical staff and the lease operator's antiquities staff. This report will be submitted to the Mining Supervisor, together with the archaeological report previously discussed.

4. AESTHETIC VALUES

Existing aesthetic values will be considered in planning and design of all facilities required for implementation of the Partial Exploration Program. Scenic values will be assessed in terms of three types of factors: physical features, biologic features and human interest features. The relative uniqueness of these features, both positive and negative, will be evaluated singly and in conjunction with related values.

Existing conditions will be documented photographically prior to initiation of any data collection and monitoring activities, which will be conducted in a manner intended to minimize visual impacts. Facilities will be designed to blend with the surrounding terrain to the fullest extent possible. Aesthetic impacts will be limited in duration by prompt implementation of rehabilitation procedures following removal of facilities after completion of monitoring, drilling and other activities.

F. FISH AND WILDLIFE MANAGEMENT PLAN

Definite consideration will be given to fish and wildlife in and about the sites during the environmental baseline study period. This will be especially true in the case of game species which are harvested by sportsmen annually.

The intensity of consideration will be based to a great degree on information received from the Utah Division of Wildlife Resources. In the past man-days use on the area has been low, with peaks of intense use occuring during the hunting seasons. With the increase of people in the area on a year-around basis and their associated activities, a definite influence on wildlife will occur.

Prior to the initiation of actual baseline and monitoring studies, interviews with Utah Division of Wildlife Resources, Bureau of Land Management and the United States Sport Fisheries and Wildlife personnel will be conducted. Aerial and ground observations on the site and surrounding areas will also be conducted, with personnel from these agencies in attendance. The purpose of these preliminary meetings and observations is to help eliminate or minimize possible inseparable damage to the fish and wildlife (especially rare or endangered species) and the associated habitat. Primary emphasis will relate to those sites or areas where the greatest amount of human activity will occur during the baseline study period. This would include, but not be limited to:

1) drilling sites
2) air and water monitoring stations
3) clearings for roads and power lines

A coordinated effort between all agencies and groups involved in the baseline study will be maintained. In some instances alternative sites and designated times for studies will be used to minimize damage to fish and wildlife and the associated habitat.

Nesting sites for raptors, especially those not tolerant of man's presence and activities, such as the Peregrine Falcon (Falco Peregrinus) will be identified and efforts made to reduce or eliminate activities during the nesting period. The presence of any prairie dog communities whcih could also support Black-footed Ferrets (Mustelo negripes) will also be noted. Power lines to monitoring sites will be designed in such a manner as to reduce or eliminate Golden Eagle mortality, especially during the winter months when numerous birds may occupy the area.

As other problems arise or are found to exist during the baseline study period immediate corrective measures will be initiated to eliminate or minimize the problem.

Problems could arise during those periods such as big game and upland game hunting seasons. Direct conflicts between on-site personnel and their associated activities and sportsmen-hunters could occur. Steps will be taken to inform on-site personnel of the seasons and possible areas of greatest hunter activity. The assistance of the State of Utah, Division of Wildlife will be

solitited in this effort. The sites will be posted advising the sportsmen of activities in the area and seeking their cooperation in minimizing possible conflicts and dangers.

Methodology involved in establishing baseline data on wildlife will be specifically designed to avoid injury or mortality to the concerned populations. These measures will include, but not be limited to:

1) Use of live traps
2) The use of accepted marking techniques which have been verified as having minimum adverse effect.
3) Consideration of established wildlife and livestock movement patterns in design of transportation corridors.
4) Interaction with conservation groups (Audubon Society, Ecological Society of America, National Wildlife Federation, etc.)
5) Reduction of human activity to minimum levels during critical periods (breeding, hatching, etc.)

G. AERIAL PHOTOGRAPHY AND TOPOGRAPHIC MAPPING

Various techniques will be utilized throughout the course of the program in support of data collection, recording and monitoring activities. These will include photogrammetric techniques to produce topographic maps and use of color, color infared and false color photography for specialized studies such as photogeology and biological monitoring.

Topographic and photogeologic mapping will be performed on the basis of initial aerial surveys which are now in progress. Photography for topographic mapping purposes will be done in color on a scale of 1"=1000' (1:12,000) while photography for photogeologic work will be done on a 1"=2000' (1:24,000) scale. Conventional black-and-white and color photography will be used to define drainage patterns, strike, and dip and general vegetative characteristics. Uncontrolled color photographs have been taken at 1:1000 and 1:2000 scales, to date.

Black-and-white, color, infrared and false color techniques will be employed for biological mapping at appropriate intervals during the two year baseline period to monitor seasonal changes in biomass and productivity. Color infrared will be utilized in the vegetative mapping process, using a scale of 1"=500' (1:6,000) allowing for greater detail in interpretation. This technique will be used primarily in summer months (March to October) to identify distribution of plant species and communities and to define their density, phenology, and condition. This will be

supplemented by the use of black-and-white infrared photography, which is more suitable for year-round use, to provide an ecological record during the winter months of more dormant conditions.

SECTION VII

SITE FACILITIES AND OPERATIONS

SECTION VII

SITE FACILITIES

A. SITE PREPARATION AND CONSTRUCTION

(1) It is presently contemplated that temporary on-tract facilities and related construction-installation work necessary for conducting the environmental program will include the following:

- Water quality monitoring stations
- Meteorological and air quality monitoring stations
- Security trailer and first-aid station
- Drilling rig sites (for ground water exploration program)
- Power line extensions (to serve monitoring stations, etc.)
- Access roads

At this time, no office, living, laboratory or storage facilities (other than temporary equipment storage) are planned for location within the tract boundaries.

(2) Minor pads, piers and protective structures will be required for the stream gauging and surface water quality monitoring stations to be located on the White River and tributaries on and adjacent to the tracts. It is presently contemplated that approximately 12 water quality monitoring stations will be installed to provide complete coverage.

(3) Two (2) 100-foot high instrumented meteorological towers and a minimum of eight (8) air quality monitoring stations will be located on or adjacent to the tracts. The towers will re-

quire foundations and guy anchors and level pads must be provided for the stationary air quality monitoring trailers. Sites will be fenced to minimize damage from vandalism.

(4) Electric power service will be extended into the tract where feasible to provide power to the water quality, meterological and air quality monitoring stations, security trailer and first-aid trailer.

(5) A security service trailer and a first-aid station will be located adjacent to the main entry road from Highway 45 into the east boundary of Tract U-b. The security trailer will be approximately 160 square feet in area and the first-aid station will be approximately the same size. A single trailer with equivalent area may be selected in lieu of individual units. These facilities will require a generally level site with adjacent parking space required for 3-4 vehicles. Power for lighting and heating and telephone service will be required.

(6) Level pads will be required for drill rigs during the ground water exploration drilling phase.

(7) It is anticipated that some new road extensions will be necessary to provide year-round access to monitoring stations and drilling sites. However, maximum efforts will be extended to locate these facilities and operations so as to utilize existing roads and trails and minimize the need to extend or augment these routes.

(8) Prior to final site selection for any environmental monitoring facilities, drilling facilities, roads, power lines,or support facilities, the proposed sites and routes to be used for those purposes will be inspected by qualified scientists to assure that no rare or scientifically significant species, objects of historic interest, or special features, such as springs, will be disturbed. The Mining Supervisor will be immediately informed if any such species or objects are found. If it is impractical to relocate proposed facilities to avoid disturbance of the sites, the investigating scientists will delineate methods of mitigating any environmental impacts which might be anticipated as a result of the construction or operation of support facilities. They will also document the nature of the existing environment in order to assist in restoration and rehabilitation of disturbed areas.

Sites for monitoring stations, drill rigs, access roads and power lines will, to the extent possible, be selected to minimize land disturbance and environmental degradation.

B. ACCESS REQUIREMENTS

Access to Tracts U-a and U-b is provided by Utah State Highway 45 from Bonanza, Utah. The road enters Tract U-b on the north and runs diagonally across the northeast corner of the tract. An unimproved road branches off Highway 45 on the northernmost section of Tract U-b and runs diagonally to the southwest corner of the tract. This road enters Tract U-a at the south-

western corner and meanders across the tract, leaving at the southwestern corner. Unimproved trails branch off at several points (see Plate 2).

Needs for access during the exploration period are varied. Included are requirements for vehicular access to drill sites for equipment, materials and operating crews, access for servicing and sampling the various baseline data monitoring stations, and access for personnel and equipment necessary to the comprehensive environmental assessment to be undertaken.

Existing roads will be utilized to the greatest extent practicable to minimize construction of new roads and concomittant grading and land use. Improvement and expansion of the existing road system will be accomplished only to the minimum extent necessary to satisfy the above requirements.

The State of Utah and the County of Uintah maintain the road facility intended for primary use, including snow-clearing during the winter period. It is possible that county jurisdiction and funding will be ultimately extended to service oil shale industry needs, however, such is not anticipated to occur during the initial two (2) year monitoring period.

In the interim, it is planned that the lease operators will extend and augment the state and county maintenance efforts using all-weather access.

Final design of primary service roads, incorporating the use

of existing roads alignments and integrating multiple-use corridors to the greatest practicable extent, will be undertaken during the exploration period for submittal with the Detailed Development Plan. The roads and trails will be located, constructed, and maintained in accordance with applicable provisions of the leases. Drainage structures, culverts and erosion control measures will be incorporated for all new and upgraded roads to minimize and control erosion and other environmental damage.

The lease operators intend to restrict on-site vehicle and construction equipment travel to the extent practical to confine such travel to existing roads and trails whenever possible. The principal on-site vehicular activity will consist of the moving of drilling equipment and personnel, the installation and servicing of baseline data collection stations and equipment, and on-site travel of environmental field research teams.

C. CORRIDOR PLANNING

Section 2 of the lease environmental stipulations sets forth requirements for developing multi-use corridor plans for roads, pipelines and utilities on the lease tracts for approval by the Mining Supervisor. The stipulations specify that such plans shall include major design features and proposed plans for the protection of the environment, prevention of pollution, minimization of erosion, rehabilitation and revegetation of all

disturbed areas not required in the operation of the transportation system, both during and after construction.

It is intended that the planning and site selection process for such facilities required to implement and support the initial exploration program will involve an overlay technique whereby environmentally sensitive areas (wildlife habitats, archaeological sites, etc.), unstable materials, flood plains and other natural barriers and fire hazard areas are identified and located in the early planning stage. Final siting of monitoring stations, drill sites, and temporary access-utility corridors will then be developed to avoid disturbance of these areas, or acceptable mitigation measures submitted for approval and implemented where significant disturbance is unavoidable.

In the environmental program and related explanation work phase, it is planned that existing roads and facilities will be utilized to the extent possible, in order to defer construction of substance and until after comprehensive planning studies have been made. The advantage of multiple land use through corridor planning vis-a-vis individual route selection for each facility is noted in the lease and has been stressed by the Bureau of Land Management. Planning efforts will be aligned to this concept.

Planning and analysis of multiple use corridors will be a significant element of the Detailed Development Plan (DDP). However, a prerequisite to defining such corridors is

the solution of several major questions facing the development, e.g. the availability and location of substantial quantities of power, the major markets for the product(s), and the settlement location of permanent personnel employed by the industry. Following study and determination of these questions, final corridor planning will be undertaken and recommendation included in the DDP.

Initial corridor studies will be complete and comprehensive in nature and detail with all feasible alternatives and routes evaluated.

D. OFF-SITE FACILITIES

As presently planned, office, housing, laboratory and warehouse storage facilities required in support of the environmental program will be located off-site to minimize environmental disturbance on the tracts during the on-going baseline monitoring period.

Field office facilities will consist of mobile trailers providing space initially for approximately 12 environmental scientists and support personnel.

Field laboratory facilities will be provided in a mobile trailer adjacent to the field office for preliminary analysis of water quality samples and preparation and storage of other specimens and samples collected during the program. Approximately 400 square feet of space will be provided. Equipment will include

balances, drying ovens, microscopes, laboratory tables and distilled water storage.

Warehousing storage space (approximately 400 square feet) will be provided by a mobile trailer for temporary storage of various samples (soils, drill cores, etc.), monitoring equipment spare parts, and other miscellaneous equipment.

Some temporary living quarters will be provided adjacent to the field office-laboratory facilities for field personnel requiring over-night accommodations near the tract site. Living, sleeping and cooking facilities will be provided for 4 people in a mobile trailer unit. The remainder of the environmental field program personnel will probably be housed in facilities in a nearby town (Vernal, Utah or Dinosaur Colorado) and commute to the site during the initial data collection program.

As presently planned, the field office, laboratory and storage trailer units will be situated at the town of Bonanza, Utah, with field personnel commuting to the site as required.

E. SAFETY, FIRE PREVENTION AND OTHER CONTROL MEASURES

Protective measures for the prevention of air pollution, fire, soil erosion, damage to fish and wildlife habitat, and prevention of health and safety hazards will be employed. Road construction, drill site preparation, and wastewater pond construction are activities which could potentially generate

dust pollution. Diligent application of water and possibly other wetting agents may be used to control dust pollution. Measures to protect fish and wildlife habitat are described in Section VIII and erosion control is discussed in Section IX.

It is not anticipated that flammable liquids will be stored on-site during the baseline study phase of the program, as laboratory and chemical storage facilities will be located off-site. Further, fire prevention and safety regulations will be adhered to during all drilling and construction activities. Use of explosives is not anticipated for either the mobilization phase or the implementation phase of the environmental baseline study program.

All drill holes, excavations and other similar improvements will be marked and protected to prevent injury to persons, livestock or wildlife. General public access will not be restricted except in those areas where activities (drilling, earthwork operations, etc.) might present a hazard to the visitor. All operations will be conducted in compliance with applicable federal, state and local statutes, regulations and safety standards.

No open burning is contemplated at this time. If any should be necessary, the required permits will first be obtained.

The conduct of every employee entering the site will be in accordance with good health and safety practices. In the

unlikely event that an injury occurs, a first-aid trailer containing emergency medical supplies meeting OSHA standards will be located on-site. In addition, communication equipment which may be used to contact nearby medical facilities and fire stations may be provided at strategic locations. Field personnel will be equipped with mobile citizen's band radio equipment which could be used for establishing contact in case of emergency.

SECTION VIII

SOCIOECONOMIC BASELINE DATA COLLECTION

SECTION VIII

SOCIOECONOMIC BASELINE DATA COLLECTION

As part of the baseline monitoring and data collection, data will be compiled pertaining to existing socioeconomic conditions in the region surrounding the project site. This would focus primarily on the communities of Bonanza, Ouray, and Vernal and the remainder of Uintah County.

The impacts of the monitoring program itself will be relatively minor, due to the small number of personnel involved, and will be largely confined to the settlement of Bonanza (5 miles north of the site) where office and laboratory facilities will be located.

It is not possible to evaluate the magnitude of population growth impacts resulting from the actual construction and mining operations without employment projections (yet to be developed); however, baseline data on existing socioeconomic conditions will be collected for possible growth areas, including Bonanza, Ouray, Vernal and communities in adjacent areas of Colorado.

Basic data will be collected pertaining to population density, distribution and general characteristics, employment and income, land use and zoning, utilities, transportation, tax base, public schools, recreation and community services. This data would be compiled from Bureau of Census statistics, and material obtained from State, county and local agencies. Consultation will be

made with regional planning agencies, public institutions active in the area and private developers where relevant. This information will provide a profile of existing socioeconomic conditions.

These research activities will provide the background information necessary to prepare a complete full socioeconomic assessment of growth impacts. This more complete study could only be performed after submitted of the Detailed Development Plan including employment figures. Once these figures and the project phasing are established, effects on existing communities and specific housing demands, and the need for development or expansion of utilities, schools and transporation facilities can be determined. This material will also serve as a comparative base for long-range regional planning to accommodate mineral development-related growth in the entire area, including expansion of existing settlements and development of possible new communities.

SECTION IX

SCHEDULE OF MANPOWER REQUIREMENTS

SECTION IX

SCHEDULE OF MANPOWER REQUIREMENTS

The following table provides an estimate of on-tract manpower requirements over the initial two (2) year environmental baseline data collection and monitoring period. Not all of the personnel will be on-tract at any given time, although they will be executing assignments in the area that directly relate to the program. As will be noted, the peak period of activity occurs in the 3rd and 4th quarters of 1974 when sites are being prepared, equipment installed and other initial baseline data is being collected.

TABLE 2

PROGRAM SCHEDULE AND MANPOWER REQUIREMENTS

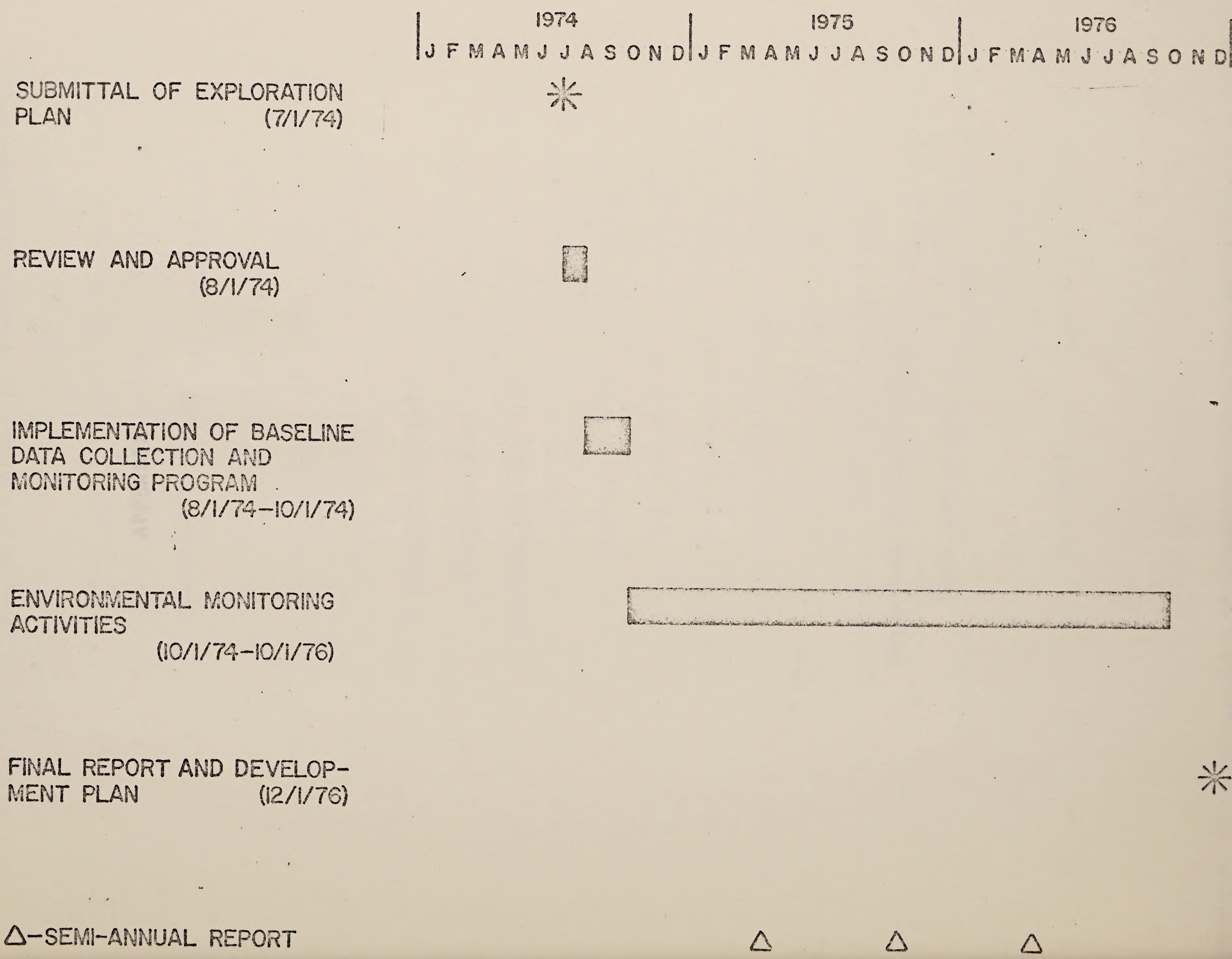
(ENVIRONMENTAL PROGRAM)

Year	1974				1975				1976			
Quarter	1st	2nd	3rd	4th	1st	2nd	3rd	4th	1st	2nd	3rd	4th
BIOLOGY AND SOILS		(8/1)										
Average On-Tract Employees			6	6	4	4	4	4	4	4	4	4
METEOROLOGY AND AIR QUALITY		(8/1)										
Average On-Tract Employees			5	3	2	2	5	2	2	2	2	2
SPECIAL ENVIRONMENTAL STUDIES		(8/1)										
Average On-Tract Employees			4	4								
SURFICIAL GEOLOGY AND HYDROLOGY		(8/1)										
Average on-Tract Employees			18	10	5	4	2	2	2	2	2	2
SUPPORT ROADS AND FACILITIES		(8/1)										
Average On-Tract Employees			13	5	4	4	3	3	3	3	3	3
TOTAL ON-TRACT EMPLOYEES			46	28	15	14	14	11	11	11	11	11

ENVIRONMENTAL BASELINE DATA COLLECTION AND MONITORING ELEMENT SCHEDULE

PREPARED BY: VTN

PLATE 3



APPENDIX

RECEIVED JUN 17 1974

REPORT OF A PRELIMINARY ARCHEOLOGICAL SURVEY OF FEDERAL OIL OIL SHALE LEASE TRACTS U-a AND U-b, UINTAH COUNTY, UTAH

by

Gardiner F. Dalley

A SPECIAL REPORT
Prepared For
VTN COLORADO, INC.

Department of Anthropology
University of Utah

June 1974

ARCHEOLOGICAL RECONNAISSANCE

This report describes the conduct and results of a preliminary archeological survey accomplished under an agreement between VTN Colorado, Inc. and the Department of Anthropology, University of Utah. The area surveyed was limited to Federal Oil Shale Lease Tracts U-a and U-b, Uintah County, Utah, as described in the Federal Register, Vol. 38, No. 230, page 33187. Actual field work was accomplished in early June by Mr. Gardiner F. Dalley an advanced graduate student with several years experience in archeological field techniques and procedures.

As per agreement, the survey was conducted as a preliminary area reconnaissance, with the primary objective of obtaining an initial assessment of the intensity of aboriginal occupation/utilization of the area. To this end, about 100 discrete locales were inspected that in the judgment of the surveyor held good potential for showing evidence of occupation. In addition, about a dozen random transects of 1/2 mile or less were walked through portions of the area. Areas of particular interest were Evacuation Creek and Southam Canyon, and especially, the low ridges perpendicular to and overlooking the White River in Section 14. Because of the rugged nature of much of the area and the limited time available to conduct the survey, all areas inspected were in close proximity to the roads providing access to the lease tracts. This procedure is considered adequate for a sampling operation, but

obviously cannot be regarded as a thorough and exhaustive survey procedure.

Results of the initial inspection were wholly negative. No discrete occupation sites were found, nor were any evidences of general occupation located, such as widely scattered debris, rock art, etc. The character of the country does not particularly suggest attractiveness for prehistoric groups, save the less steep and rugged areas bordering the White River. Nonetheless, it was somewhat surprising to have found nothing in the area as much of Uintah County is archeologically very rich and some utilization of peripheral areas would normally be expected.

From previous work done by the Bureau of Land Management, there is a record of one site (42Un324) in the lease area (see Attachment 2). This is noted as being a partially sheltered area along a small outcrop; the only evidences of occupation observed were a few stone chips and bone scraps, along with some charcoal. Also, there are a few sites recorded outside the lease area, but still in oil shale country and not far removed from tracts U-a and U-b (see Attachment 1).

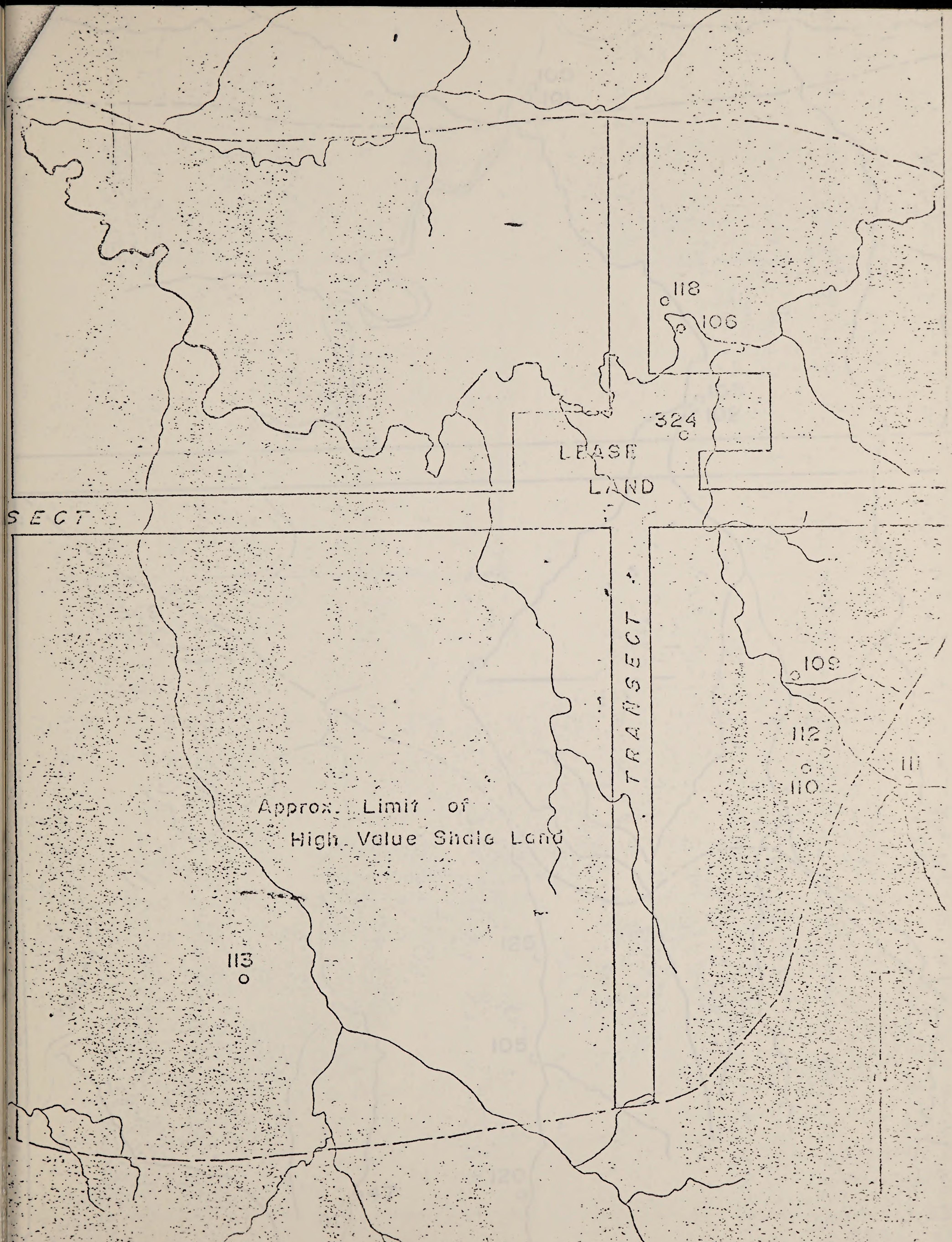
HISTORIC SITES

Outside the specific scope of this report, but of concern to a complete impact study are the numerous historic values of the general area. Included are the Ignatio Stage Station; the route of the narrow-gage Uinta Railroad and the Gilsonite mines it served; the stage and

telegraph lines running from Vernal to Watson to Nine Mile Canyon; and the ghost towns of Dragon, Watson and Rainbow. Additionally, one historic site (42Un352) was recorded during the survey that is just slightly north of the lease boundary in Sec. 11 (see Attachments 2 and 3). Some impact on these locales and facilities can be expected if development is undertaken in the oil shale areas. Mr. Curtis Tucker, Recreation Specialist with the Bureau of Land Management Office in Vernal is reported to control considerable data on these historic sites.

FINDINGS

In conclusion, the results of the preliminary survey of lease areas U-a and U-b tentatively indicates that development will entail only minimal impact on archeological resources. As noted above, however, this report can only be considered as an initial assessment involving sampling of a small percentage of the area included in the leases. A thorough survey of the entire area will still be required before a final and precise assessment and impact statement can be made.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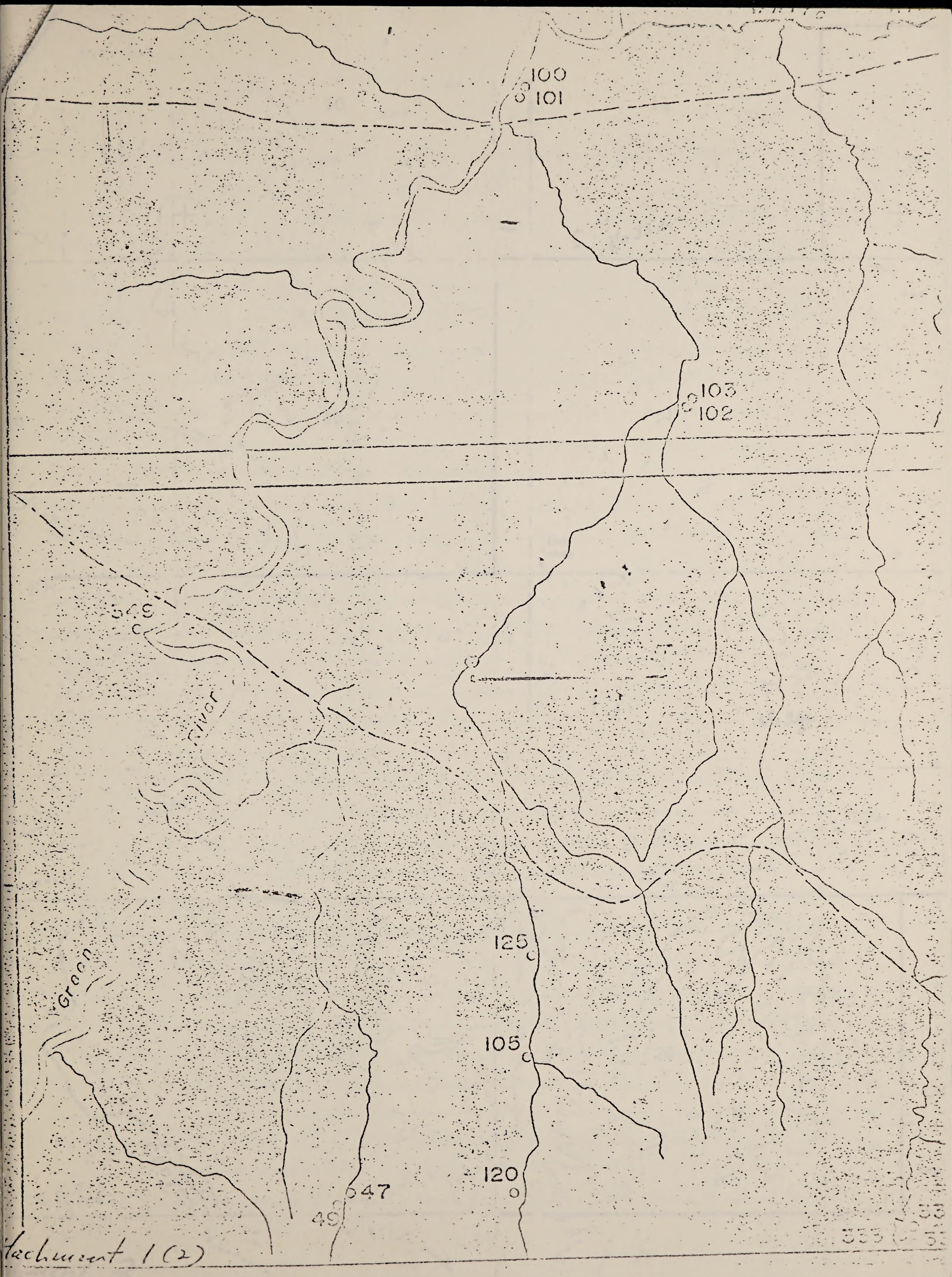

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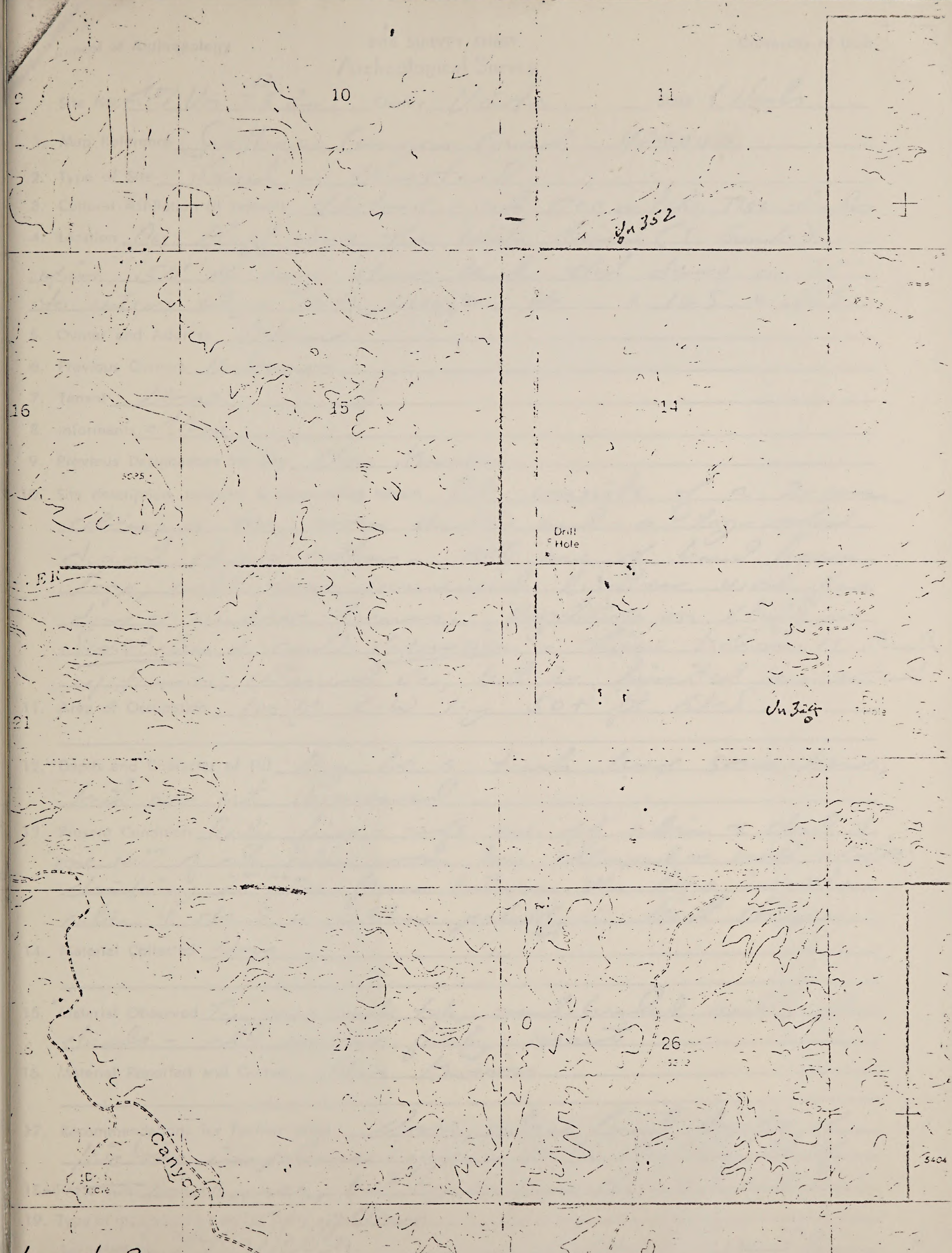
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rtment of Anthropology

SITE SURVEY SHEET
Archeological Survey

University of Utah

Site No. 42 Un 352 County Uinta State Utah

1. Map Reference Southam Canyon Quad 1/24000
2. Type of Site Ranch or Homestead
3. Cultural Affiliation (if known) Historic - post 1900 or late 1800 Anglo
4. Location On bluff above the White River (S. bank) w/in 50' of very steep bank that drops ca 75' to waters edge NE¼, NW¼ Sec. 14 T. 10S R. 24E
5. Owner and Address Unknown
6. Previous Owners Unknown
7. Tenant None
8. Informants None
9. Previous Designations for Site None Known
10. Site description, position, & surrounding terrain Site consists of a 2-room cabin, a one room shed(?) and a log-roofed dugout storage cellar. All are of hand hewn logs, with some commercial lumber used for doors & window frames. Vegetation on bluff is Sarcobatus & small Artemisia - River bottom is lush w/ tamarix, cottonwood etc, but is limited in extent
11. Area of Occupation 100 ft E-W by 50+ ft N-S
12. Depth and Character of Fill May be a trash heap somewhere, but was not observed.
13. Present Condition Only fair - roofs are off cabin & shed & one wall of one cabin room has collapsed - most adobe chinking is gone from between the logs in the cabin & shed - cellar probably in best shape.
14. Material Collected None
15. Material Observed Tin cans, wash tub, round-headed nails, glass sherds - all appear fairly recent
16. Material Reported and Owner None Known
17. Recommendations for Further Work None, unless found to be of historic importance - appears to be slightly W. of
18. ~~Photo Nos.~~ [illegible] area, but by no more than 0.7 mile
19. Type of map made by survey party None

Recorded by K. J. Dalley Date 15 June 74